An Econometric Analysis Of the Markets for SOYBEAN OIL and SOYBEAN MEAL

R. J. Vandenborre

UNIVERSITY OF ILLINOIS COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION BULLETIN 723

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This bulletin was prepared by R. J. Vandenborre, Assistant Professor in the Department of Agricultural Economics, University of Illinois. The bulletin is an extensive revision of the author's doctoral dissertation. The author gratefully acknowledges the assistance of Professors T. A. Hieronymus and G. G. Judge of the Department of Agricultural Economics, University of Illinois, during the completion of the dissertation. The assistance of Kalman Blum, Assistant in the Department of Agricultural Economics, University of California at Berkeley, is also acknowledged.

Urbana, Illinois March, 1967

Publications in the Bulletin series report the results of investigations made or sponsored by the Experiment Station.

AN ECONOMETRIC ANALYSIS OF THE MARKETS FOR SOYBEAN OIL AND SOYBEAN MEAL

By R. J. Vandenborre

Before world war ii, Asia (except Japan) and Africa were the principal exporters of edible vegetable oils and oilseeds. North America, Europe, and Japan were the leading importers. During the postwar period, however, the United States has emerged as the most important exporter in these commodities *(10,* p. 31*)*.[1]

The oilseed crop most responsible for the actual United States position is soybeans. As an indication of the change over time, the production of soybeans rose from 200 million bushels in 1946-47 to 700 million bushels in 1963-64. Soybeans are now fourth among the leading cash crops, behind cotton, wheat, and corn, and are the leading dollar export crop.

As is the case with feed grains, the United States government supports the production of soybeans not only through the establishment of a support price but, even more important, through the export of considerable quantities of soybean oil for foreign currency or as outright gifts. In practice, this has resulted in a price for soybean oil higher than what free-market forces would bring (under the assumption of given supplies) and in a basically free-market price for meal.

Information relative to the cause-and-effect relations in question is of vital importance for decision-making purposes. In economics, this information is generally provided by an economic analysis of the relevant past experience and a sensible appreciation of possible changes in the future. Economic analysis of past experience, however, usually suffers from two shortcomings. It lacks quantitative accuracy and it often leaves a particular question unsettled. Based on sound economic and statistical concepts, it is the role of quantitative methods to confirm and define more accurately knowledge from economic analysis of past experience and, if at all possible, to resolve questions where economic analysis does not provide a definite answer.

Important determinants in the markets for soybean oil and soybean meal are in need of quantification. In the past, a divergent demand for soybean meal and soybean oil developed at an essentially free-market price for meal and supported price for oil. What is the extent of this divergence? Could it easily be remedied? If so, by what action? It is still an open question whether the demand for soybean oil and meal here

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[1] This and similar references are listed in Literature Cited on pages 54-55.

and abroad is elastic or inelastic. There is no accurate estimate of the influence of foreign oil supplies on the markets for soybean oil and meal. It is not known how much P.L. 480 shipments push up the price of soybean oil in the hard-currency markets. Trend influence is heavy in both markets and it is important to get a better idea of its magnitude. This study attempts to give answers to these problems.

The bulletin is organized into four sections. Because the setting of the study is rather complex, a descriptive survey to provide background information forms the content of the first section. The second section presents an economic and statistical model of the soybean oil and soybean meal markets. The basis for the economic model is the general theoretical framework derived from classical economic theory and assumptions and observations relating to the sector itself. The results are presented in the third section. They are analyzed for their economic and statistical validity and compared with available parameter estimates obtained by other researchers. The last section is devoted to the implications and conclusions that can be drawn from the results.

THE SOYBEAN OIL AND SOYBEAN MEAL MARKETS: A DESCRIPTIVE SURVEY

The Place of Soybean Oil

Fats and oils can be subdivided in several ways, depending upon the criterion that is used. According to their origin, they can be classified as vegetable, animal, and marine fats and oils. If their use is considered, some will be classified edible, others inedible, while some may be used for inedible and edible purposes at the same time. The most useful and logical classification is based upon the chemical properties of fats and oils *(2; 14,* Dec. 1953, pp. 1-16*)*.

Chemically, fats and oils are the result of a union of glycerol and fatty acids. Glycerol is an alcohol with the formula $C_3H_5(OH)_3$. A fatty acid consists of a chain of carbon atoms of a COOH group to which hydrogen atoms are attached. Fatty acids differ by their number of C-atoms and by the number of hydrogen atoms attached. When all the possible positions for hydrogen atoms are occupied, the fat is saturated. Fats with vacant hydrogen positions are comparatively unsaturated. Listing the main categories of fats and oils, using the criterion of an increasing degree of saturation, there are drying oils; soybean oil; edible vegetable oils (olive oil, sesame seed oil, groundnut oil, cottonseed oil, and sunflower seed oil); rapeseed oil; whale and fish oils; lard, greases, tallow, and palm oil; coconut oil and palm seed oils; and milk fats. Except for drying oils, fish oils, greases, and tallow, all these fats and oils are used mainly for edible purposes. Before World War II, palm oil was extensively used for soap; since the war, that use has declined, and the use for margarine and compound cooking fats has increased rapidly, especially in Western Europe *(27,* pp. 252-254*)*.

Directly competing with soybean oil for the use in food products are edible vegetable oils, rapeseed oil, whale oil, coconut and palm seed oils, lard, butter, and palm oil. Domestically, cottonseed oil and lard are the most important competitors. It is in the export markets of Western Europe and Japan that American oils (especially soybean oil) face competition from domestic European and Japanese oils (olive oil, soybean oil, and rapeseed oil) and Asian (coconut oil) and African oils (groundnut oil, palm oil, and palm-kernel oil). A realistic model for soybean oil demand must take these forces into account.

Production of Fats and Oils[2]

The production of a particular commodity is a function of its relative profitability, the case of entry and exit in and out of production, technological progress, and possibly public regulation. Because of World War II with the destruction of groves and depletion of livestock herds and because of the revolutionary war in China, availabilities of fats and oils for the non-Communist world were below prewar levels during the years 1945-1949. High prices did not result in a fast expansion of production. First of all, many fats and oils are by-products. Their production is not only a function of their own price but also of the price of other joint products. Some oils contribute very significantly to the total value but others, such as cottonseed oil, only to a very limited extent. Second, the forces stimulating soybean oil production were only beginning to come into existence. Third, the raw products of many fats and oils have a particular production period. When planted in the spring, soybeans, cotton, and groundnuts give fruit in the fall. But many oilseed crops are perennial. It takes a palm tree about 7 years to bear fruit for the first time, and for an olive tree this period is about 15 years. As a consequence, production response is greatly delayed. Moreover, high oil prices for some years will not necessarily result in the planting of additional trees. Because of the great amount of capital invested in a highly specialized product, the long-run outlook is of much greater importance. Also, it might require several years of good care to bring a grove to normal yields after a period of neglect. With respect to animal fats, the same remark holds because a herd has to be built up gradually.

[2] This study will not involve the U.S.S.R., mainland China, and Eastern European countries because there is not sufficient information for a reliable analysis.

Data on world production of edible fats and oils are summarized in Table 1. The table shows that since the early 1950's production of oilseed crops has more or less stagnated except for soybeans and groundnuts. The production pattern takes on specific significance if it is considered along geographical lines. Soybeans for soybean oil in the non-Communist world are predominantly produced in the United States.

Table 1. — World Availabilities of Fats and Oils (Without the Communist Bloc),[a] 1947-1961

Year (t)[b]	Olive oil	Sesame oil	Rapeseed oil	Sunflower seed oil	Cotton seed oil	Soya oil	Ground-nut oil
			1,000 metric tons				
1947	732	345	429	199	1,065	1,103	2,524
1948	1,164	372	438	297	1,263	1,125	2,608
1949	450	418	492	358	1,483	1,249	2,508
1950	1,160	427	594	247	1,708	1,314	2,583
1951	582	494	615	337	1,407	1,676	2,614
1952	1,494	447	675	253	1,736	1,620	2,571
1953	827	472	693	209	1,875	1,713	2,595
1954	1,209	501	621	196	1,923	1,564	3,045
1955	1,013	561	687	163	1,922	1,926	3,073
1956	795	519	644	282	1,985	2,107	3,225
1957	1,154	517	725	242	1,883	2,476	3,456
1958	1,103	517	786	279	1,822	2,649	3,763
1959	1,065	561	807	190	1,886	3,135	3,947
1960	1,131	502	774	304	2,001	2,918	3,571
1961	1,322	473	894	255	2,138	3,033	4,059

Year (t)[b]	Lard	Whale oil	Palm oil	Palm-kernel oil	Copra oil	Total	Total per capita
			1,000 metric tons				*kilograms*
1947	1,423	370	272	213	1,018	9,693	6.22
1948	1,458	405	358	240	1,143	10,871	6.79
1949	1,660	441	441	245	1,093	10,838	6.68
1950	1,823	443	469	269	1,131	12,168	7.38
1951	1,967	503	461	239	1,415	12,310	7.36
1952	2,063	495	499	263	1,281	13,397	7.85
1953	1,810	436	559	288	1,244	12,721	7.34
1954	1,807	487	584	299	1,315	13,551	7.66
1955	2,025	470	549	276	1,451	14,116	7.81
1956	2,114	495	564	245	1,620	14,595	7.99
1957	2,010	498	559	283	1,567	15,370	8.32
1958	1,978	518	551	248	1,293	15,507	8.28
1959	2,173	496	566	305	1,253	16,384	8.54
1960	2,085	490	558	300	1,580	16,214	8.22
1961	2,150	507	536	288	1,609	17,264	8.51

[a] The Communist bloc includes the U.S.S.R., mainland China, North Korea, and Communist Eastern Europe. For palm oils, only the most important producing countries are included.
[b] The year (t) refers to oilseeds and their oils harvested late in the preceding years and in the beginning of year (t). For palm oil, palm-kernel oil, and copra oil, harvesting is done throughout the year but is heaviest in the early part.
Sources: For palm oils, *(6)*; for others, *(15)*.

Its production has increased regularly and is increasing at the present time. Although palm oil and palm-kernel oil production in Africa has remained fairly constant, its groundnut oil production is expanding but at a smaller rate than American soybean production. The production of coconut oil and groundnut oil in Asia, on the other hand, is stagnating *(10,* p. 12*)*.

The trade pattern emerging from this is a flow of fats and oils from the United States, Asia, and Africa to Europe and Japan. The United States is increasing its importance in the import markets. Africa holds its ground with respect to the exports of palm oil, palm-kernel oil, and groundnut oil. Exports of Asian groundnut oil which occurred on a limited scale about 1950 have disappeared and Asia remains only as an important supplier of coconut oils.

Consumption

Total per capita consumption of fats and oils in Western Europe and North America has reached the saturation point. Nevertheless, edible vegetable oil consumption keeps increasing, mainly because of the use of more vegetable oils and less animal fats in diets and a changing composition of diets. In a recent article, R. P. Dahl sees an increasing divergence between the demand for soybean oil and soybean meal in Western Europe in favor of soybean meal *(7)*. This will very probably be true, but the possible divergence should not be exaggerated. Total per capita consumption of fats and oils in Western Europe reached a plateau with the marketing year 1956-57 (see Table 2). United States commercial exports of soybean oil to Europe (oil plus oil equivalent of beans), deleting Spain, were 318 million pounds, 555 million pounds, and 418 million pounds in 1955-56, 1956-57, and 1957-58 respectively. For the years 1948-49 and 1949-50, they amounted to 414 million pounds and 295 million pounds. It was therefore not soybean oil that contributed greatly in reaching the present plateau of fats-and-oils consumption in Europe but rather the increased production of oils from Asia and Africa during the first half of the 1950's. With total per capita consumption in Europe more or less stabilized since 1956-57, commercial exports of United States soybean oil nevertheless grew to 879 million pounds and 1,017 million pounds in 1961-62 and 1962-63, respectively, again deleting Spain.[3] This indicates a shift toward more vegetable oil consumption, the same shift present in the United States.

[3] The absolute amount of exports from Africa and the Asian coconut-producing countries was roughly the same for the periods 1955-1957 and 1961-1962. Exports from Communist China decreased considerably, but its trade was mainly with the Eastern European Communist bloc and Japan. On the other hand, note that the use of palm oils for soap was decreasing in favor for use as a cooking oil.

Table 2 gives an idea of the difference in per capita consumption of edible vegetable oils and lard in three important geographical areas. The rest of the world which is actually an exporter is only a surplus region in an economic, not a dietary sense. Although they probably will never consume the same amount of fats as do the Europeans and North Americans *(3,* p. 60-61*)*, consumption could easily triple, and their fat intake would still be on the lower side.

The United States Soybean Sector

A phenomenal rise in the production of soybeans in the United States took place between 1940 and 1960. The main reasons for this expansion were World War II, cutting off foreign supplies for the United States and driving it toward self-sufficiency, the control programs in the United States on wheat and feed grains and cotton, the disappearance of Communist China as a supplier of importance to the non-Communist bloc, the rising dependence of European consumers on

Table 2. — Consumption in Absolute Amounts and Per Capita of the Most Important Edible Fats and Oils (Except Butter) in the United States, Western Europe, Japan, and Other Non-Communist Countries, 1947-1961[a]

Year (t)[b]	United States		Europe and Japan		Other non-Communist countries	
	Total in thousands of metric tons	Per capita in kilograms	Total in thousands of metric tons	Per capita in kilograms	Total in thousands of metric tons	Per capita in kilograms
1947	2,047	14.35	2,887	8.48	3,643	3.37
1948	2,182	15.02	3,627	10.01	3,703	3.37
1949	2,253	15.26	3,549	9.70	3,622	3.26
1950	2,426	16.15	4,355	11.82	4,061	3.59
1951	2,397	15.86	4,344	11.71	4,282	3.72
1952	2,552	16.63	5,171	13.83	4,250	3.60
1953	2,623	16.81	4,552	12.05	4,555	3.79
1954	2,634	16.55	4,874	12.81	4,831	3.92
1955	2,825	17.40	4,721	12.31	5,422	4.29
1956	2,717	16.43	5,202	13.47	5,183	4.08
1957	2,702	16.04	5,489	14.12	5,844	4.52
1958	2,831	16.51	5,475	13.96	6,082	4.64
1959	2,943	16.84	5,429	13.71	6,049	4.49
1960	3,099	17.39	5,926	14.87	5,578	3.99
1961	3,152	17.40	5,827	14.48	6,550	4.53

[a] Includes soybean oil, cottonseed oil, olive oil, sesame seed oil, rapeseed oil, groundnut oil, palm oil, palm-kernel oil, copra oil, whale oil, and lard.
[b] The year (t) refers to oilseeds and their oils harvested late in the preceding year and in the beginning of year (t). For palm oil, palm-kernel oil, and copra oil, harvesting is done throughout the year but it is heaviest in the early part.
Sources: For the United States, *(31)*; for Europe, Japan, and other non-Communist countries, *(15)* and *(16)*.

other than their traditional suppliers, the discovery of soybean meal as a high-protein feed by the United States and European livestock economy, and favorable relative prices.

The United States soybean market is closely connected with the world markets for fats and oils and the Western European livestock sector. There are no import duties on beans and meal and duties on oil are very low (about 5 percent ad valorem) except for France and Italy where they are in the neighborhood of 15 percent ad valorem. The tariff structure has been very stable in the past and is likely to remain so in the future *(7,* p. 981*)*.

Table 3 shows the utilization of soybeans in terms of soybean oil. Soybean oil exports in oil form increased from around 300 million pounds in 1948-49 to over 1,100 million pounds in recent years. The majority of this increase consisted of P.L. 480 exports. The P.L. 480 program for soybean oil started in 1955-56, and 286 million pounds were shipped out under the program. Exports of this nature rose to 746 million pounds during the marketing year 1958-59 and since then have varied between 600 and 700 million pounds. P.L. 480 oil exports

Table 3. — Supply and Disposition of Soybean Oil in the United States, 1947-1964

Marketing year[a]	Available soybeans (production and stocks in all positions)	Oil from domestic crushing	Beginning oil stocks	Domestic disappearance	Oil exports (oil form)	Bean exports, oil equivalent
	millions of bushels			*millions of pounds*		
1947-48	191.8	1,534	204	1,532	112	27
1948-49	229.8	1,807	96	1,488	300	225
1949-50	237.4	1,937	113	1,646	291	128
1950-51	302.2	2,454	113	1,906	490	272
1951-52	287.9	2,444	171	2,150	271	167
1952-53	302.4	2,536	194	2,462	93	320
1953-54	279.3	2,350	174	2,326	71	436
1954-55	342.4	2,711	127	2,609	50	666
1955-56	379.1	3,143	179	2,539	556	741
1956-57	452.5	3,431	227	2,565	807	937
1957-58	493.3	3,800	286	3,051	804	939
1958-59	604.8	4,251	281	3,304	930	1,209
1959-60	593.0	4,338	298	3,376	953	1,552
1960-61	577.5	4,420	308	3,329	721	1,431
1961-62	697.1	4,790	677	3,540	1,308	1,685
1962-63	716.3	5,091	618	3,624	1,165	1,984
1963-64	714.4	4,822	920	4,060	1,104	2,102

[a] Beginning October 1.
Source: *(31)*.

form a price support for oil in the longer run. Short-run price supports to both oil and meal occur through Commodity Credit Corporation acquisitions and subsequent sales in the domestic market. These operations have been minor, and therefore meal prices are basically free market prices.

Domestically, soybean oil is used almost entirely for food purposes. The main factors responsible for an expanding use in food are stabilization of cottonseed oil production, use of more animal fats than vegetable fats, encouragement of this trend through favorable prices, greater use of vegetables and outdoor meals, increased use of salad oils and dressing oils, and population increase.

Soybean meal production and utilization are summarized in Table 4. The use of soybean meal has expanded greatly here and abroad through increases in number of animals, better feeding technology rapidly distributed by the formula-feed industry and poultry contracts, and use of antibiotics, increasing the efficiency of high protein meals and at the same time using them as a vehicle for distribution.

AN ECONOMETRIC MODEL OF THE UNITED STATES SOYBEAN OIL AND SOYBEAN MEAL MARKETS

The model developed in this section will serve as a basis for quantitative estimation and is intended to yield structural estimates that are useful for gauging consequences of alternative courses of action. Every econometric model draws its information from three sources: the existing body of economic knowledge, the particular characteristics of the sector in question, and the body of statistical techniques available. Construction of an economic model using economic principles and empirical knowledge and of a statistical model transforming and conditioning the economic model so as to make it feasible for probabilistic estimation and prediction purposes will be considered.

The Economic Model

When processed, soybeans yield meal and oil in a fixed proportion. The demand structure for soybean meal is entirely different from that for soybean oil. But can it also be said that the supplies for domestic use and exports, once the harvested quantities of beans are given, are determined independently from each other? We have to consider the supply of beans at two points in the marketing system: supplies in the hands of the farmer and the beans acquired by processors. The processor will pay the farmer a price per unit equal to the revenue he re-

Table 4. — Soybean Meal Supply and Disposition in the United States, 1948-1949 to 1963-1964

Marketing year[a]	Disposition in bean form				Disposition in meal form				Total availability	Domestic use	Total free ending stocks
	Ending free stocks	Exports	Total	Meal equivalent	Feed	Exports	Ending stocks	Total			
	million bushels			*1,000 short tons*	*1,000 short tons*				*1,000 metric tons*		
1948-49	3.2	23.0	26.2	615.7	4,178	151	13	4,342	4,502	3,794	80.1
1949-50	2.9	13.1	16.0	376.0	4,543	47	35	4,625	4,541	4,125	93.7
1950-51	4.2	27.8	32.0	752.0	5,748	181	36	5,965	6,099	5,219	90.0
1951-52	3.6	17.0	20.6	484.1	5,670	42	52	5,764	5,673	5,148	124.0
1952-53	10.1	31.9	42.0	987.1	5,540	47	57	5,644	6,021	5,030	267.3
1953-54	1.3	39.7	41.0	963.5	4,945	67	62	5,124	5,528	4,535	84.1
1954-55	3.3	60.9	64.2	1,508.7	5,458	272	37	5,767	6,607	4,956	104.1
1955-56	3.7	67.5	71.2	1,673.2	6,071	400	111	6,582	7,496	5,512	179.8
1956-57	4.7	85.4	90.1	2,117.4	7,123	443	55	7,621	8,842	6,468	150.3
1957-58	7.2	85.5	92.7	2,178.5	7,992	300	48	8,340	9,551	7,257	197.2
1958-59	4.5	110.1	114.6	2,693.0	8,968	512	58	9,538	11,104	8,143	146.6
1959-60	13.5	141.4	154.9	3,640.2	8,479	649	83	9,211	11,669	7,699	363.5
1960-61	6.0	130.1	136.1	3,198.4	8,867	590	78	9,535	11,562	8,051	198.9
1961-62	6.6	153.2	159.7	3,755.2	9,262	1,064	94	10,420	12,871	8,410	225.4
1962-63	13.4	180.3	193.7	4,552.0	9,586	1,476	159	11,221	14,322	8,704	430.3
1963-64	21.4	191.1	212.5	4,993.7	9,162	1,484	122	10,768	14,306	8,319	562.0

[a] Beginning October 1.
Source: *(31)*.

ceives from the meal and the oil per unit processed minus a charge for his services. There also exists a price per unit that the government is willing to pay. If the processor cannot pay a higher price than the government does, the farmer seeking the best price will sell his beans to the government. Observe that the individual prices for oil and meal do not determine the amount sold to the government; it is the combined revenue that is important. Furthermore, supplies of oil and meal to processors are diminished in a fixed ratio by sale to the government which buys only beans, not oil or meal.

The next question is whether it can be determined beforehand what amount of beans the government will buy up in any given year, or, in other words, whether the government takeover is an exogenous or an endogenous variable. The following two equations may be written:

$$P_{bt} = f(P^*_{bt}, T_t)$$
$$T_t = f(P^*_{bt}, S_{pt})$$

where

P_{bt} = actual market price of beans in t.
P^*_{bt} = freemarket price of beans in t.
T_t = government takeover in t.
S_{pt} = support price for beans in t.

For the case $P^*_{bt} \geq S_{pt}$, it may be assumed that $T_t = 0 + e_{1t}$ where e_{1t} is a normally distributed disturbance term with zero mean and constant variance. The other possibility involves $P^*_{bt} < S_{pt}$. In this case, $P_{bt} = S_{pt} + e_{2t}$, and the government could remove a quantity T_t from the market so that the expression holds. The only information it would need is the supply in farmers' hands and knowledge about the demand curves for oil and meal so that it can estimate P^*_{bt}. The government, however, does not do this and leaves it to the market to define T_t. But the market does not have a range of values within which T_t and P_{bt} can be defined. Given the profit maximizing motive and S_{pt}, there is only one possible value for T_t so that $P_{bt} = S_{pt} + e_{2t}$. Therefore, the simultaneity between P_{bt} and T_t in this case is only apparent, not genuine. The government came into the market only seven times during the period 1948-49 through 1963-64. In five out of the seven instances, the takeover was insignificant, amounting to less than 2 percent. Only in 1958-59 and again in 1961-62 did the takeover amount to 7 percent. The general insignificance of the takeover alone is sufficient to subtract these from the quantity of beans available at harvest time. In an analogous way, government sales of beans can be added to harvested quantities.

With respect to beans in the hands of processors, it is perfectly possible for them to hold stocks in either bean form, meal form, or oil form. This opportunity is not available, however, for nonprocessor holders of beans. It is therefore possible that meal is held in bean form because of changes in oil prices and that oil is held in bean form because of changes in meal prices. Oil prices are of a more speculative character than meal prices, and it may therefore be expected that the price of soybean oil will have a greater effect on meal held in the form of beans than the price of meal will have on oil holdings in bean form. Total ending stocks of beans in all positions, except government stocks and resealed beans, have varied from 2 to 14 million bushels, or up to 3 percent of availabilities. This is an amount that cannot be said to have exceeded the quantity necessary for the continuity of crushing operations. Nevertheless, if stock functions for oil and meal are built, they should allow for the possibilities mentioned above.

Ending stocks of soybean oil under all forms then depend partly on the average price of soybean oil and soybean meal. It is known that the soybean oil price is quite an uncertain variable from year to year, primarily because soybean oil is part of the international fats-and-oils market. Speculation in soybean oil has therefore occurred often. In order to separate the holding of stocks in the case of falling prices from the speculative holding of soybean oil when prices are rising, production may profitably be introduced as an exogenous variable. Furthermore, ending stocks also depend on P.L. 480 shipments. Trial runs on the equation for ending stocks of soybean oil showed meal price to be entirely insignificant and this variable was therefore dropped. Ending stocks of meal in all forms were made dependent on the soybean oil price and the soybean meal price.

Following classical economic theory, the domestic wholesale disappearance of soybean oil for food is assumed to be a function of its wholesale price, the wholesale price of the closest competitor (cottonseed oil), the availabilities of butter and lard, and a trend variable. From observation, it is evident that total per capita consumption of fats and oils does not respond to income changes. In fact, the quantity consumed per capita has been very stable over the past two decades. This is the reason why income has not been included as an exogenous variable in the domestic demand equation. The trend variable will then capture two influences: first, the population increase and second, the shift from animal to vegetable fats and oils, and in particular, to soybean oil. Because population increases are known and stable, the shift of the demand curve for the second reason can be determined. The equation will yield own and cross elasticities of demand. Because the income effect is assumed to be zero,[4] those elasticities are a measure of total substitutability (own elasticity of demand) and substitutability with respect to cottonseed oil (cross elasticity). It must be understood that the determination of elasticities and cross elasticities will occur under the usual *ceteris paribus* assumptions, in other words, under the assumption of what would happen if other prices and quantities are constant whether or not they are likely to be so in reality *(4)*. It may be assumed, although this is not fully true, that the availabilities of butter and lard can be considered as given. This is, of course, not true at all for the price of cottonseed oil; but it is relevant to take the supply of cottonseed oil as predetermined. Another equation will, therefore, be estimated, in which the price of cottonseed oil is considered to be a function of the price of soybean oil and the availabilities of cottonseed oil in the United States. From both equations the actual change in the demand of soybean oil for a change in its price can be deduced, other quantities assumed known. Furthermore, both equations will furnish information with respect to the stability of the different fats-and-oils markets in the United States.

The theoretical development here follows the treatment by J. R. Hicks of the working of the general equilibrium system among commodities *(19,* pp. 62-77*)*. Soybean oil can be designated by Y; cottonseed oil by X; and butter, lard, and other vegetable fats and oils by T. The domestic demand equation for soybean oil and the cottonseed oil price equation will indicate whether the markets for X and Y are stable, taken by themselves. A negative own price elasticity of demand for soybean oil means that this market is stable. Stability in the cottonseed oil market is suggested by a negative sign on cottonseed oil availabilities in the cottonseed oil price relation. The question then is whether a market stable for one commodity by itself can be rendered unstable by reactions through other markets.

Hicks starts with the analysis of the effect on a market X of reactions through the market of Y (the prices of T being given). Along the y axis is measured the price of Y and along the x axis the price of X. Arbitrary prices of Y are selected, and corresponding prices of X

[4] In this case the income elasticity of demand is presumably zero. The income effect can also be neglected in the case where the income elasticity of demand is not zero, but the product of this factor and the share of expenditures on the commodity in question with respect to total expenditure is very small. This follows from the expression

$$n_{px} = sx \times n_{ix} + (1 - sx)n_{sx}$$

where n_{px} = price elasticity of demand for good x; sx = proportion of income spent on x; n_{ix} = income elasticity of demand for good x; and n_{sx} = elasticity of substitution for good x.

are determined that will equate the supply and demand for X, thus bringing the X market into equilibrium. The locus of points on the diagram, representing particular pairs of prices, is called the x′x curve. In the same way, a y′y curve can be constructed by taking arbitrary prices of X along the y axis, corresponding prices of Y which equate the supply and demand for Y along the x axis and reversing the axis so that we can represent both curves in one diagram with the price of Y on the y axis and the price of X along the x axis. The case can be extended to the group T. The conclusions are:

If X and Y are substitutes, x′x slopes upwards and y′y slopes upwards.

If X and Y are complementary, x′x slopes downwards and y′y slopes downwards.

If X is a substitute for both Y and T, the curve x′x slopes upwards with an elasticity smaller than unity.

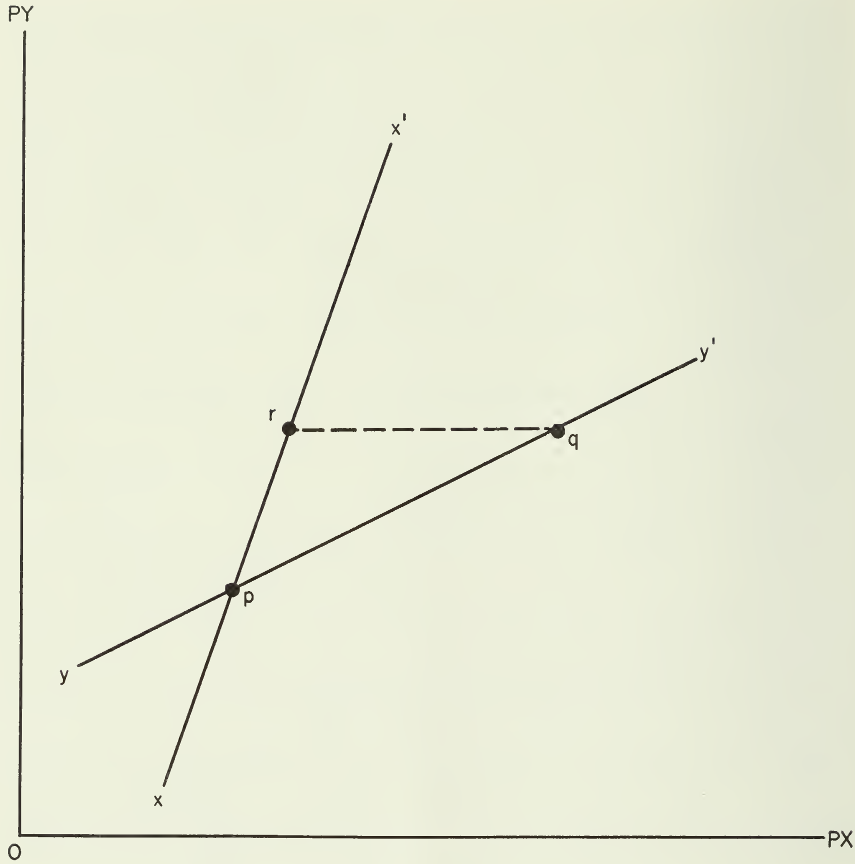
If Y is a substitute for both X and T, y′y will slope upwards, and its elasticity will be greater than unity (from reversing the axis).

If X and T are complementary, x′x slopes upwards with an elasticity greater than unity.

If Y and T are complementary, y′y slopes upwards with an elasticity smaller than unity (from reversing the axis).

These results can now be used to examine the stability of a system of markets. In the illustration on page 16, the point P represents a pair of prices at which both markets are in equilibrium. They will be in stable equilibrium if a rise in the price of X reacts on the price of Y and this price reacts on the price of X to lower it. At a price of X above the equilibrium level, the market for Y would, for example, be in equilibrium at Q. At this price of Y, however, the market for X would come into equilibrium at R on x′x, a price closer to the equilibrium than the starting point. The condition for this to occur is that x′x should have a greater slope than y′y. In the case of X, Y, and T all being substitutes for one another, this condition is fulfilled; the slope of x′x is positive with an elasticity smaller than one, and the slope of y′y is positive with an elasticity greater than one. Of course, mutual substitutability is not the only case where the system of markets constitutes a stable equilibrium.

A priori, it should be expected that soybean oil, cottonseed oil, and all other food fats and oils are mutual substitutes. Therefore, the x′x curve should slope upwards with an elasticity smaller than unity (a rise in the price of Y should raise the price of X less than proportionately).



As a consequence, the coefficient on the soybean oil price in the cottonseed oil price relation should be smaller than one and positive. Also, the $y'y$ curve should slope upwards with an elasticity greater than unity. Consequently, the coefficient on the cottonseed oil price in the demand equation normalized on the soybean oil price should be smaller than one and positive.

On the basis of classical economic theory, the domestic demand for soybean meal for feed will depend upon its price, the availability of competing high-protein feeds, animal numbers, and livestock prices.

The next set of important behavioral relationships involves the exports of meal, oil, and beans. Just as there is no final demand for beans in the United States, there is no final demand for beans in the export markets. Therefore there are only two export functions: one for oil shipped under whatever form, and one for meal and the meal equivalent of bean exports. Europe and Japan only import beans to the extent that oil and meal needs cover each other. If this were not so, they would periodically be faced with the problem of exporting meal or oil. This is practically not feasible as they would meet overwhelming competition from P.L. 480 exports and commercial exports of soybean oil from the United States and from other oils whose prices do not have to include the costs of going through an additional marketing channel. Furthermore, European and Japanese crushers cannot compensate for an artificially low export price of soybean oil by higher prices for the meal. There are world markets in soybeans, oil, and meal and the lack of import duties on meal and the low duties on oil prevent such a compensation. As a matter of fact, European and Japanese exports of soybean oil (and of all oils for that matter) have been negligible *(16)*.

Exports of oil and meal to Western Europe, Japan, and Canada will be singled out from total exports. They normally amount to 85 percent of total commercial exports. Exports from the United States to Canada are often exports in transit whose final destination is Western Europe. Separation of exports along these geographical lines is necessary because exports to Western Europe, Japan, and Canada are not hampered by frequent changes in commercial policy and the important determinants of those exports can be identified. P.L. 480 shipments and other exports lack these characteristics. A trial was made to explain the other exports through trend and price. The results were totally insignificant and these exports were subtracted from total availabilities. It is assumed that no significant error was introduced by this procedure.

The first determinant to consider in the oil export function is the price of oil. Two price series are available: crude midwestern mills price in the United States and the c.i.f. price in Europe. Movements in both series have been parallel throughout the period under observation, and the difference has been around $20 per metric ton *(14)*. The United States price can, therefore, be used as a price variable.

With respect to competing oils, those were selected that have been of predominant importance, either in the trade to Europe and Japan or domestically grown in Europe and Japan. Included are all vegetable oilseeds grown in Europe and Japan; whale oil; groundnut oil from western Africa;[5] palm oil and palm-kernel oil from western and central Africa;[6] coconut oil from the Philippines, Ceylon, Malaysia, and Indonesia; and butter and lard production in Europe and Japan. Production of butter and lard constitutes one variable; the production of the other fats and oils has been aggregated in a second exogenous variable.

[5] Nigeria and former French West Africa (Dahomey, Guinea, Mali, Niger, Senegal, and Upper Volta).

[6] For palm oil: Nigeria, former Belgian Congo, and Indonesia; for palm-kernel oil: Nigeria, former French West Africa, and former Belgian Congo.

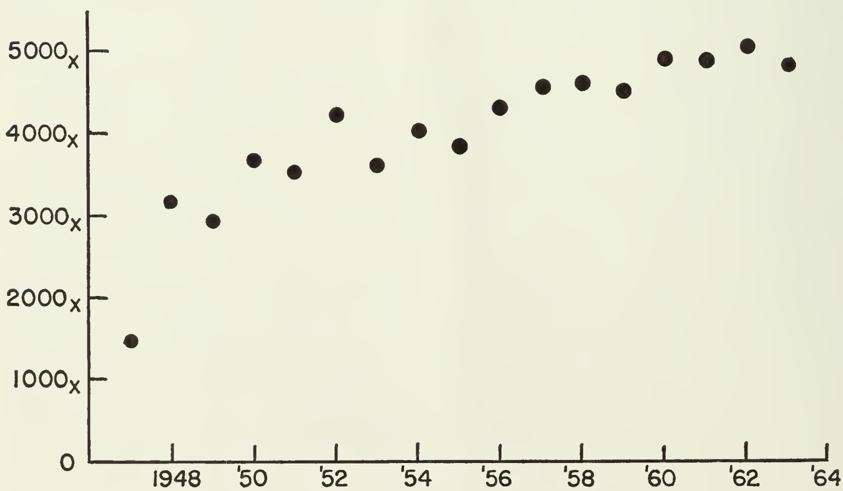
United States exports of soybean oil to Western Europe and Japan are undoubtedly influenced by the stock positions in edible fats and oils of those areas *(12)*. Because there are no data on stocks available, a proxy variable intended to reflect the abnormal stock accumulations and decumulations was constructed. The total of internally produced fats and oils, except butter and lard, and net imports of food fats and oils, again without butter and lard, was regressed on the logarithm of time (starting at 1) for the period 1947-1963. The result of this regression was (in 1,000 metric tons):

$$X = 1{,}856.7901 + \underset{(203.1914)}{2{,}541.0902} \log T$$

$$Sxy = 280.8864 \qquad R^2 = 0.913 \qquad d = 2.65.$$

The regression was made on the logarithm of time because of the declining importance of income shifts. From this equation, actual unknown consumption was predicted, and the difference between availabilities and predicted consumption in t_{-1} was considered as an accumulation or decumulation of stocks. For an estimation of the export function using absolute values, existing stocks can be taken as being zero at the start of the observation period. Using first differences of the data for estimation would not restrict use of this more or less arbitrary choice of intercept. In the figure below the variable X as defined here has been plotted against time as an example.

A trial run on the export equation showed butter and lard to be totally insignificant with a positive coefficient and a slight change in the



trend variable as compared with an estimation without the butter and lard variable. Furthermore, data on butter and especially lard production are reported with big gaps for some important countries in the Food and Agriculture Organization of the United Nations (FAO) statistics *(15)*. Also, the classification of rendered and unrendered pork fat is not too reliable. The variable was therefore dropped from the analysis.

When the composition of the diets of people in countries with different income levels is considered, root crops are usually found to be important at low income levels, fats and oils to gain importance as income rises, and finally meats and vegetables to play a primary role at very high incomes. Europe and Japan are somewhere on the border line between the second and third stage. It appeared interesting to see if there might be some substitution of fats and oils for meat products in case of high prices of livestock and livestock products. Prices of European livestock (for which reliable data and a set of weights were found) were, therefore, introduced as a determinant of United States soybean oil exports. From the results, it appears that this hypothesis might have some validity.

Because oil exports occur predominantly under bean form, it is possible that low meal prices might encourage oil exports for storage purposes. Trial results indicated, however, that this was not the case.

Three obvious demand shifters for soybean oil in Europe, Japan, and Canada are the trend towards more vegetable fat consumption, population increases, and income. Income was important for total fats and oil consumption for this geographical group from the late 1940's to the middle 1950's. However, it has been mentioned that soybean oil had a minimal share in this rapid increase in per capita consumption of food fats and oil. Income has, therefore, been excluded from the equation. Trend and population increases have been represented by time.

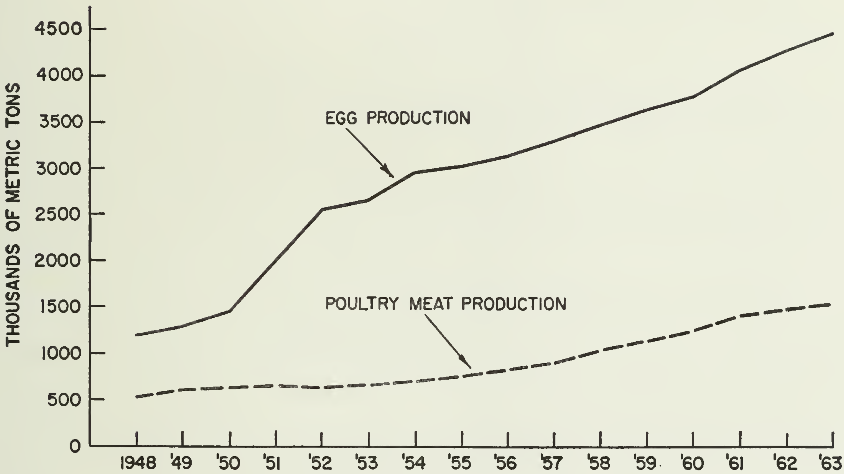
Exports of soybean meal (under whatever form) to Europe, Japan, and Canada were thought to depend on the price of soybean meal and the price of soybean oil for the same reason as discussed under exports of soybean oil. The price of oil showed itself to be important. Livestock prices are a further determinant. There was no reliable data on Japan available, but recently the European Economic Community (EEC) published a set of weights to be given to different kinds of livestock and livestock products for EEC countries in building a livestock price index *(9)*. Also, the FAO has published price series in local currencies and dollar equivalents of leading markets of cattle, pork, and fluid milk in European countries *(15)*. With this information, livestock price indices were constructed for cattle (West Germany, Netherlands, Belgium, Italy, and France included); pork (West Germany, Netherlands, and France included); and fluid milk (West Germany, Netherlands, Italy, and France included). Because price series on Canada were also available, this country was given a weight of 10 percent in the three partial indices (roughly in proportion of its livestock population to the European livestock population). The three measures were then integrated into one with the following weights: cattle, 23.8; pork, 30.6; milk, 45.6. This index is considered representative of livestock prices throughout Europe.

Livestock numbers are another logical determinant. They were split into two groups: cattle and hog numbers as the first group and poultry numbers as the second. Unfortunately, poultry numbers have been reported with big gaps for important countries. Prices of poultry and poultry products were not included in the livestock price index because of their short production period and their consequent reflection in quantities. The FAO has regularly reported annual numbers of cattle and hogs in different countries *(15)*. A recent German article also provides weights to be assigned to cattle and hogs with respect to high protein feed consumption *(25)*. After the series were completed and introduced in the equation, however, results were disappointing. Both were insignificant with a negative sign and an adjustment on the trend variable. They were, therefore, deleted from the analysis. These results are not surprising, for a glance at the figures on the facing page indicates steady trends and the absence of hog and cattle cycles.

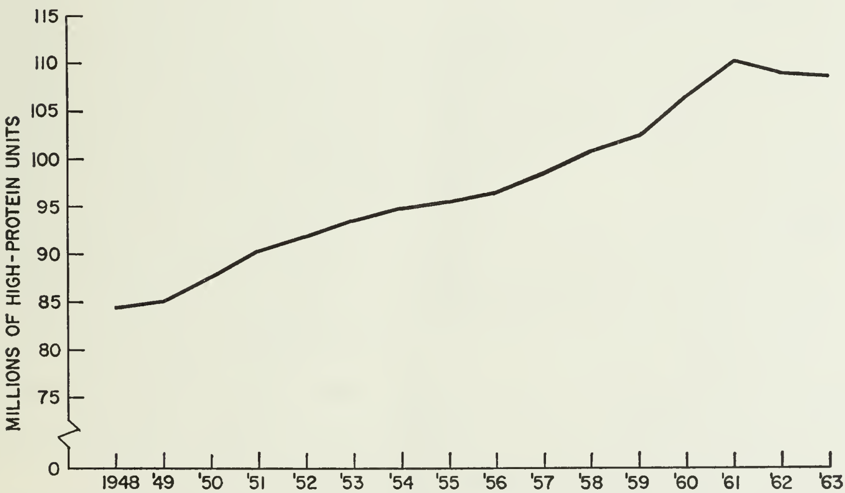
Hay and forage production in Europe and Japan can be considered another important variable on a priori grounds. Data, however, are not available. It is known that production of hay and forage is heavily influenced by weather. It can therefore be assumed that changes in hay and forage production are randomly distributed and that these changes can be absorbed in the residual.

One final behavioral equation involves the handling margin. This margin has been declining over time through the introduction of better and more efficient crushing equipment. Therefore it seems logical to let this movement be reflected by a trend variable. Between the day of sales of beans by the farmer and the day the end products are sold a considerable amount of time may elapse. It seems, therefore, also logical that prices of end products would be important, especially the price of soybean oil which is determined under greater uncertainty.

The economic model discussed may now be formalized. Endogenous variables are indicated by y_i and exogenous variables by x_i.



Egg and poultry meat production in Western Europe, 1948-1963.



High-protein numbers of cattle and hogs in Western Europe, 1948-1963.

Domestic demand equation of soybean oil for food

$$y_1 = f(y_2, y_3, x_1, \text{and } t)$$

Cottonseed oil price relationship

$$y_3 = f(y_2, x_2, \text{and } t)$$

United States exports of soybean oil (in all forms) to Europe, Japan, and Canada

$$y_4 = f(y_2, x_3, x_4, x_{10}, \text{and } t)$$

Ending stocks of soybean oil in all forms

$$y_5 = f(y_2, x_5, x_6, \text{and } t)$$

Domestic demand of meal for feed

$$y_6 = f(y_7, x_7, x_8, x_9, \text{and } t)$$

United States exports of meal (in all forms) to Europe, Japan, and Canada

$$y_8 = f(y_2, y_7, x_{10}, \text{and } t)$$

Ending stocks of soybean meal in all forms

$$y_9 = f(y_2, y_7, \text{and } t)$$

Handling margin

$$y_{10} = f(y_2, y_7, \text{and } t).$$

To close the model, there are two identities:

$$y_1 + y_4 + y_5 = x_5 - x_6$$
$$y_6 + y_8 + y_9 = x_{11}$$

where

y_1 = wholesale demand of crude soybean oil for food in the United States in 1,000 metric tons.
y_2 = crude soybean oil price in dollars per metric ton, midwestern mills.
y_3 = crude cottonseed oil price in dollars per metric ton, southeastern mills.
y_4 = exports of soybean oil under all forms to Western Europe, Japan, and Canada in 1,000 metric tons.
y_5 = ending commercial stocks of soybean oil under all forms in the United States in 1,000 metric tons.
y_6 = wholesale demand of soybean meal in the United States in 1,000 metric tons.
y_7 = price of soybean meal, Decatur, Illinois, in dollars per metric ton.

y_8 = exports of soybean meal under all forms to Western Europe, Japan, and Canada in 1,000 metric tons.

y_9 = ending commercial stocks of soybean meal under all forms in the United States in 1,000 metric tons.

y_{10} = handling margin or spread between the value of oil and meal per bushel and the average price per bushel.

x_1 = production plus starting stocks of butter and lard in the United States in 1,000 metric tons.

x_2 = production plus commercial starting stocks of cottonseed oil in the United States plus domestic government sales minus Commodity Credit Corporation (CCC) and P.L. 480 exports in 1,000 metric tons.

x_3 = Western European, Japanese, Canadian, and most important exporters' (outside the United States) production of food fats and oils (except butter and lard) in 1,000 metric ton oil equivalent.

x_4 = "proxy" variable for Western European and Japanese starting stocks of food fats and oils except butter and lard, as defined on page 18, in 1,000 metric tons.

x_5 = production plus commercial starting stocks of soybean oil under all forms in the United States plus CCC sales in 1,000 metric tons minus CCC withdrawals, exports outside Western Europe, Japan, and Canada, and industrial use and oil equivalent of feed, seed, and residual.

x_6 = P.L. 480 sales of soybean oil in 1,000 metric tons.

x_7 = availabilities of high-protein feeds in the United States, except soybean meal in 1,000 metric tons.

x_8 = United States price index of prices of livestock and livestock products.

x_9 = high-protein animal units in the United States in million units.

x_{10} = EEC and Canadian price index of prices of cattle, hogs, and fluid milk, 1958 = 100.

x_{11} = production plus commercial starting stocks of soybean meal under all forms in the United States plus CCC sales in 1,000 metric tons minus CCC withdrawals, exports outside Western Europe, Japan, and Canada, and meal equivalent of feed, seed, and residual.

t = time (1 to 16 years).

A few final remarks are in order here before the statistical model is discussed. First of all, all variables are on an October 1-September 30 basis except x_4. This variable is on a calendar year basis except for domestic production in Western Europe and Japan. All annual oilseeds and oilcrops are harvested in the fall. Oils coming from tree nuts are harvested throughout the year with the heaviest harvesting period in the spring *(17)*. We may assume a lapse of several months between harvesting time and import into Western Europe and Japan. Imports in these countries on a calendar year basis are, therefore, close to being consistent with the marketing-year period of the exporting countries.

Time has been introduced in all equations. This is certainly justified in the domestic and foreign demand equations for oil and meal because of changes in habits and feed technology. Its use in the equation for the handling margin has also been explained. Its presence in the stock equations may be somewhat less relevant, especially in the relationship on soybean oil stocks where x_5 is introduced.

From the discussion and the definition of the variables, it is seen that supplies of soybean oil and meal are completely inelastic with respect to all outlets combined. However, the introduction of stock equations has removed this assumption with respect to domestic and foreign demands for food and feed, respectively.

Finally, the data used in the estimation process have been grouped in Tables 5 and 6. Price series were not deflated, and the year 1950-51 was dropped because of the outbreak of the Korean War.

Table 5. — Endogenous Variables: Data Used in the 10-Equation Model of the United States Soybean Oil and Soybean Meal Markets, 1948-1963[a]

Year[b]	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}
	1,000 metric tons	*dollars per metric ton*		*1,000 metric tons*			*dollars per metric ton*	*1,000 metric tons*		*cents per bushel*
1948	535.6	288.2	339.2	231.3	65.0	3,794.0	72.7	597.0	80.1	53.0
1949	603.3	256.2	275.4	167.7	64.0	4,125.0	70.7	279.1	93.7	57.0
1951	811.1	248.6	285.6	174.9	107.0	5,148.0	91.7	327.1	124.0	35.0
1952	942.7	266.2	313.5	153.0	120.0	5,030.0	74.3	557.0	267.3	19.0
1953	909.0	297.0	298.5	207.1	65.0	4,535.0	86.5	818.1	84.1	62.0
1954	1,028.5	261.8	294.5	283.4	98.0	4,956.0	66.8	1,389.1	104.1	23.0
1955	996.7	275.0	286.4	372.2	121.0	5,512.0	57.8	1,668.6	179.8	39.0
1956	1,011.5	279.4	294.8	478.6	153.0	6,468.0	52.2	2,013.6	150.3	34.0
1957	1,237.2	237.6	299.2	417.1	162.7	7,257.0	58.7	1,796.0	197.2	34.0
1958	1,344.0	209.0	257.4	538.0	157.7	8,143.0	61.4	2,503.7	146.6	33.0
1959	1,362.7	182.6	220.0	733.7	207.7	7,699.0	61.1	3,253.1	363.5	24.0
1960	1,357.4	248.6	259.6	657.3	337.7	8,051.0	66.7	2,957.8	198.9	53.0
1961	1,444.2	209.0	275.0	907.6	316.8	8,410.0	70.0	3,955.0	225.4	26.0
1962	1,471.2	195.8	231.0	982.6	485.4	8,704.0	78.4	4,767.1	430.3	28.0
1963	1,669.2	187.0	220.0	930.3	370.0	8,319.0	78.1	5,112.0	562.0	13.0

[a] The year 1950-51 was dropped because of the outbreak of the Korean War.
[b] Beginning October 1.
Source: *(31)*.

Table 6. — Exogenous Variables: Data Used in the 10-Equation Model on the United States Soybean Oil and Soybean Meal Markets, 1948-1963[a]

Year[b]	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}
				1,000 metric tons				*millions*	*1914-1918 =100*	*1957-1958 =100*	*1,000 metric tons*
1948	1,682.0	933.0	3,216.0	551.0	831.9	0	5,140.0	130.9	283.9	93.0	4,471.1
1949	1,799.0	1,066.0	3,943.0	432.0	835.0	0	5,333.0	134.2	268.5	82.0	4,497.8
1951	1,800.0	938.0	4,784.0	630.0	1,093.0	0	5,591.0	137.0	316.7	96.3	5,599.1
1952	1,770.0	712.0	4,133.0	1,066.0	1,215.7	0	5,503.0	133.8	278.5	91.2	5,854.3
1953	1,753.0	1,075.0	4,686.0	688.0	1,183.1	0	6,064.0	133.5	262.9	92.4	5,437.2
1954	1,940.0	1,037.0	4,345.0	597.0	1,409.9	0	5,604.0	135.0	237.5	91.7	6,449.2
1955	2,009.0	1,036.0	4,466.0	185.0	1,619.9	130.0	5,962.0	138.4	225.5	97.3	7,360.4
1956	1,837.0	966.0	4,738.0	118.0	1,863.5	220.4	5,562.0	136.6	237.1	100.3	8,631.4
1957	1,754.0	782.0	4,887.0	198.0	2,040.6	223.6	5,319.0	135.8	268.3	100.0	9,250.2
1958	1,836.0	798.0	4,451.0	227.0	2,378.7	339.6	5,603.0	140.8	262.5	98.7	10,793.3
1959	1,869.0	991.0	4,841.0	50.0	2,575.0	270.9	5,709.0	139.6	248.9	96.9	11,315.6
1960	1,822.0	1,013.0	4,965.0	224.0	2,552.8	200.4	6,044.0	142.9	253.0	102.4	11,207.7
1961	1,926.0	927.0	5,066.0	302.0	2,962.4	311.8	6,305.0	143.3	252.7	104.7	12,590.4
1962	1,972.0	1,047.0	4,873.0	478.0	3,233.3	294.0	6,393.0	145.9	249.3	113.3	13,901.4
1963	1,972.0	1,103.0	5,591.0	381.0	3,255.6	273.1	6,709.0	147.1	236.0	115.4	13,993.0

[a] The year 1950-51 was dropped because of the outbreak of the Korean War.
[b] Beginning October 1.
Sources: For x_1, x_2, x_5, x_6, and x_{11}, *(31)*; for x_7 and x_8, *(32)*; for x_9, *(8)*; for x_3 and x_4, *(6)* and *(15)*; for x_{10}, *(9)* and *(15)*.

The Stochastic Model

Before meaningful inferences can be drawn from the model constructed in the preceding pages, it has to be cast in a proper stochastic framework. For the model presented, it is assumed that the combination of endogenous variables is a constant linear function of the exogenous variables and of drawings from populations of random disturbances. Furthermore:

(1) $EU(t) = 0$ $(t = 1, 2, \ldots T)$	(each disturbance vector has zero expectation).
(2) $EU(t)U'(t) = \Sigma$ $(t = 1, 2, \ldots T)$	(the contemporaneous covariance matrix of the disturbances in the different behavioral equations is the same for all t).
(3) $EU(t)U'(t') = 0$ $(t, t' = 1, 2, \ldots T; t \neq t')$	(the disturbance vector is temporally uncorrelated or all lagged covariances between disturbances in the same or different equations are zero).
(4) $EX(t)U'(t) = 0$ $(t = 1, 2, \ldots T)$	(the predetermined variables are contemporaneously uncorrelated with the disturbances).

Statistical theory has proven that least squares estimation of the relations in the model would result in biased estimates of the parameters. This is so because in every relation one or more of the variables designated as independent in fact depend upon the values assumed by the disturbance. These are the endogenous, jointly determined variables (y_i's) on the right-hand side of every equation. Other methods of estimation have to be used to provide at least asymptotically unbiased estimates of the parameters. For overidentified equations in a model, the ideal method would be the "full information maximum likelihood" method. This method, being very complicated and cumbersome, is usually replaced either by the "limited information maximum likelihood" method or by the two-stage least squares procedure. Both provide asymptotically unbiased estimates. However, for small sample sizes, the two-stage least squares procedure seems to be better. This assertion is based on results from Monte Carlo studies *(21,* pp. 275-295*)*. For just identified relations, indirect least squares is a correct method. Every y_i can be estimated as a function of all predetermined variables. The estimates thus obtained are called reduced form estimates. They are unbiased because of assumption (4) above. However, some of the predetermined variables in these relations have, in fact, no direct relationship to the y_i in the dependent position. The parameters on the directly relevant variables in every equation are called structural parameters, and knowledge of the structure of a system involves the computation of unbiased estimates for these parameters.

If, through algebraic manipulation of the reduced form estimates, unique estimates for the structural parameters of an equation can be derived, the equation is said to be just identified. If trivial or inconsistent estimates for parameters of a structural equation can be derived from the reduced form estimates, the equation is said to be overidentified. If an infinity of estimates for parameters of a structural equation can be derived, the equation is underidentified.

It is important to know beforehand in which category the structural relations fall. If one or more are just identified, then the reduced form estimates that are unbiased can be computed and estimates of the structural parameters of the just identified equations can be obtained through algebraic manipulation. If they are underidentified, there is no possible solution and the model must be reconsidered. For equations that are overidentified, algebraic manipulation of the reduced form estimates cannot be used but unbiased estimates of the structural parameters can be obtained indirectly through the use of other appropriate procedures (two-stage least squares, full information maximum likelihood, limited information maximum likelihood, and three-stage least squares).

The two-stage least squares procedure is relatively simple. It involves the estimation of every non-normalized y_i (or the y_i's in the independent position) as a function of all or part of the exogenous variables. If these variables are called $\hat{y}_i$, then $E\hat{y}_i(t)U'(t) = 0$ because the x's from which they are computed are contemporaneously uncorrelated with the disturbance term. Replacing every nonnormalized y_i by $\hat{y}_i$, unbiased estimates of the structural parameters of every overidentified equation may be obtained through the use of classical least squares.

The conditions for identifiability of a structural equation when the restrictions on the structural equation are exclusions of variables are simply stated here, not established.[7] In a simultaneous linear structural equation model a particular equation is identifiable if, and only if, the rank of the matrix of the reduced form coefficients of the exogenous

[7] A full treatment of this and other points dealt with here may be found in textbooks on econometric theory. See items *(18)*, *(21)*, *(23)*, and *(26)* in Literature Cited.

variables excluded from that structural equation in the reduced form relations of the included endogenous variables in the structural equation equals the number of included endogenous variables minus one. This is known as the rank condition. Because the rank of a matrix cannot exceed the number of rows of the matrix (here equal to the number of endogenous variables included in the relation), the rank condition implies that a necessary condition for a particular structural equation to be identified is that the number of exogenous variables excluded from the structural equation must be greater than or equal to the number of endogenous variables included minus one. If the number is greater, overidentification is indicated. If the number is equal, the equation is just identified. Usually, it is sufficient to check the order condition *(24)*. According to the order condition, all behavioral relations in the model presented here are overidentified. The identities are, of course, just identified with known parameter values. Consequently, the two-stage least squares procedure will be used to obtain estimates of the structural parameters of the model.

Strong trends are present in the soybean meal and soybean oil markets. There is consequently a substantial danger, through multicollinearity, that the price influences will be overshadowed if estimation proceeds using original values of the variables. If first differences of the data over the appropriate time period are used, a precise measure of both the trend and other variables may be obtained if trends were relatively constant. Information of this nature is of the highest importance in fats-and-oils markets. The use of first differences on time series data will normally result in determination coefficients significantly lower than the ones obtained from the use of the original data. The high determination coefficients obtained in many empirical studies are, in most instances, due to the presence of trends *(13,* vol. 26, pp. 21-47*)*. The R^2's in the model presented here, using first differences of the data, were mostly in the range 0.4 to 0.6. The same equations obtained R^2's of over 0.9 when the original data were used, and the coefficients did not differ substantially, except in some cases, where the cause could be found in a high multicollinearity among the exogenous variables.

Often time series data are also serially correlated. The use of first differences may offer the solution here as well. One has to be careful, however, for if serial correlation is not present in the original values, the process of differencing will introduce it in the first difference data.[8] The opposite does not necessarily hold. It will consequently be mandatory to examine the equations for possible serial correlation.

[8] Given $E(u_t u_{t-1}) = 0$, $E(\Delta u_t)\ (\Delta u_{t-1}) = E(u_{t+1} - u_t)\ (u_t - u_{t-1}) = -\sigma^2_u$.

The stochastic model, as it will be used for estimation, can now be presented:

$$\Delta y_{1t} = \alpha_1 \Delta_t + \alpha_2 \Delta y_{2t} + \alpha_3 \Delta y_{3t} + \alpha_4 \Delta x_{1t} + u_{1t} \tag{1}$$

$$\Delta y_{3t} = \alpha_5 \Delta_t + \alpha_6 \Delta y_{2t} + \alpha_7 \Delta x_{2t} + u_{2t} \tag{2}$$

$$\Delta y_{4t} = \alpha_8 \Delta_t + \alpha_9 \Delta y_{2t} + \alpha_{10} \Delta x_{3t} + \alpha_{11} \Delta x_{4t} + \alpha_{12} \Delta x_{10t} + u_{3t} \tag{3}$$

$$\Delta y_{5t} = \alpha_{13} \Delta_t + \alpha_{14} \Delta y_{2t} + \alpha_{15} \Delta x_{5t} + \alpha_{16} \Delta x_{6t} + u_{4t} \tag{4}$$

$$\Delta y_{6t} = \alpha_{17} \Delta_t + \alpha_{18} \Delta y_{7t} + \alpha_{19} \Delta x_{7t} + \alpha_{20} \Delta x_{8t} + \alpha_{21} \Delta x_{9t} + u_{5t} \tag{5}$$

$$\Delta y_{8t} = \alpha_{22} \Delta_t + \alpha_{23} \Delta y_{2t} + \alpha_{24} \Delta y_{7t} + \alpha_{25} \Delta x_{4t} + u_{6t} \tag{6}$$

$$\Delta y_{9t} = \alpha_{26} \Delta_t + \alpha_{27} \Delta y_{2t} + \alpha_{28} \Delta y_{7t} + u_{7t} \tag{7}$$

$$\Delta y_{10t} = \alpha_{29} \Delta_t + \alpha_{30} \Delta y_{2t} + \alpha_{31} \Delta y_{7t} + u_{8t} \tag{8}$$

$$\Delta y_{1t} + \Delta y_{4t} + \Delta y_{5t} = \Delta x_{5t} - \Delta x_{6t} \tag{9}$$

$$\Delta y_{6t} + \Delta y_{8t} + \Delta y_{9t} = \Delta x_{11t} \tag{10}$$

where t, y_i, and x_i have been previously defined. The period of observation runs from the marketing year 1948-49 through 1963-64 with the deletion of 1950-51 because of the Korean War. The two-stage least squares procedure will be used on first differences of the data.

RESULTS OF THE STATISTICAL ESTIMATION

The previous section has provided a theoretical and statistical framework for the empirical work that was to be carried out. In this section, the results of confronting the models with the data via estimation procedures will be presented. The resulting estimates will be examined to determine their agreement or disagreement with respect to economic theory and circumstantial evidence. Coefficients will be given in four significant digits. The estimated standard error of each coefficient appears beneath in parentheses. The standard errors of estimate on the equation are denoted by S. The Durbin-Watson statistic for measuring serial correlation in disturbances is denoted by d. The coefficient of multiple determination is shown as R^2. Single least squares estimates, although biased, will be given for comparison. The two-stage least squares estimates and ordinary least squares estimates of the eight behavorial equations are:

Domestic demand for soybean oil for food purposes

$$\Delta y_{1t} = 79.6702\,\Delta_t - \underset{(0.9346)}{2.03733}\,\Delta y_{2t} + \underset{(0.9314)}{1.2506}\,\Delta y_{3t} - \underset{(0.2925)}{0.13358}\,\Delta x_{1t} + \bar{u}_{1t}{}^{9} \qquad \text{(2SLS)}$$

$$S = 81.56 \qquad d = 1.53\text{(i)}^{10}$$

[9] $\bar{u}_{1t}$ will refer to the residual from 2SLS estimation; $\bar{\bar{u}}_{1t}$ will refer to the residual from ordinary least-squares estimation.

[10] If the symbol (i) follows the statistic, the Durbin-Watson test for serial correlation of the error term was inconclusive; the symbol (n) indicates that the test showed no serial correlation.

$$\Delta y_{1t} = 79.6775\,\Delta_t - \underset{(0.7799)}{2.2924}\,\Delta y_{2t} + \underset{(0.8141)}{1.4391}\,\Delta y_{3t} - \underset{(0.2575)}{0.14598}\,\Delta x_{1t} + \bar{\bar{u}}_{1t} \qquad \text{(OLS)}$$

$S = 72.21 \qquad d = 1.46\text{(i)} \qquad R^2 = 0.48$

Cottonseed oil price relationship

$$\Delta y_{3t} = -2.26354\,\Delta_t + \underset{(0.1512)}{0.63938}\,\Delta y_{2t} - \underset{(0.0288)}{0.13414}\,\Delta x_{2t} + \bar{u}_{2t} \qquad \text{(2SLS)}$$

$S = 15.97 \qquad d = 2.35\text{(n)}$

$$\Delta y_{3t} = -2.6492\,\Delta_t + \underset{(0.1543)}{0.58897}\,\Delta y_{2t} - \underset{(0.0305)}{0.13238}\,\Delta x_{2t} + \bar{\bar{u}}_{2t} \qquad \text{(OLS)}$$

$S = 16.97 \qquad d = 2.28\text{(n)} \qquad R^2 = 0.73$

United States exports to Western Europe, Japan, and Canada

$$\Delta y_{4t} = 42.5122\,\Delta_t - \underset{(0.8789)}{1.6405}\,\Delta y_{2t} - \underset{(0.0621)}{0.1013}\,\Delta x_{3t} - \underset{(0.1225)}{0.2073}\,\Delta x_{4t} + \underset{(4.4902)}{6.3936}\,\Delta x_{10t} + \bar{u}_{3t} \qquad \text{(2SLS)}$$

$S = 90.00 \qquad d = 2.22\text{(n)}$

$$\Delta y_{4t} = 44.5811\,\Delta_t - \underset{(0.8719)}{1.41615}\,\Delta y_{2t} - \underset{(0.0643)}{0.1006}\,\Delta x_{3t} - \underset{(0.1269)}{0.2064}\,\Delta x_{4t} + \underset{(4.6334)}{6.0509}\,\Delta x_{10t} + \bar{\bar{u}}_{3t} \qquad \text{(OLS)}$$

$S = 93.21 \qquad d = 2.30\text{(n)} \qquad R^2 = 0.44$

Ending soybean oil stocks

$$\Delta y_{5t} = -29.6691\,\Delta_t + \underset{(0.7356)}{1.0667}\,\Delta y_{2t} + \underset{(0.1934)}{0.4227}\,\Delta x_{5t} - \underset{(0.3409)}{0.7187}\,\Delta x_{6t} + \bar{u}_{4t} \qquad \text{(2SLS)}$$

$S = 62.59 \qquad d = 2.42\text{(i)}$

$$\Delta y_{5t} = -33.9962\,\Delta_t + \underset{(0.6374)}{1.3161}\,\Delta y_{2t} + \underset{(0.1747)}{0.4605}\,\Delta x_{5t} - \underset{(0.3134)}{0.7401}\,\Delta x_{6t} + \bar{\bar{u}}_{4t} \qquad \text{(OLS)}$$

$S = 57.65 \qquad d = 2.43\text{(i)} \qquad R^2 = 0.48$

Domestic demand of soybean meal for feed

$$\Delta y_{6t} = 335.2347\,\Delta_t - \underset{(17.5467)}{25.6025}\,\Delta y_{7t} - \underset{(0.4800)}{0.4160}\,\Delta x_{7t} + \underset{(37.7129)}{103.7382}\,\Delta x_{8t} + \underset{(7.3547)}{22.0823}\,\Delta x_{9t} + \bar{u}_{5t} \qquad \text{(2SLS)}$$

$S = 274.799 \qquad d = 2.07\text{(n)}$

$$\Delta y_{6t} = 334.5592\,\Delta_t - \underset{(16.5484)}{28.6346}\,\Delta y_{7t} - \underset{(0.4561)}{0.3491}\,\Delta x_{7t} + \underset{(36.2831)}{102.1581}\,\Delta x_{8t} + \underset{(6.9702)}{23.1999}\,\Delta x_{9t} + \bar{\bar{u}}_{5t} \qquad \text{(OLS)}$$

$S = 264.70 \qquad d = 2.19\text{(i)} \qquad R^2 = 0.82$

Exports of meal to Western Europe, Japan, and Canada

$$\Delta y_{8t} = 232.3612\,\Delta_t - \underset{(12.3892)}{13.7423}\,\Delta y_{7t} - \underset{(3.9837)}{6.1382}\,\Delta y_{2t} + \underset{(23.2508)}{31.9179}\,\Delta x_{10t} + \bar{u}_{6t} \qquad \text{(2SLS)}$$

$S = 407.2928 \qquad d = 1.66\text{(n)}$

$$\Delta y_{8t} = 228.8581\,\Delta_t - \underset{(12.1001)}{13.3005}\,\Delta y_{7t} - \underset{(3.7457)}{6.5585}\,\Delta y_{2t} + \underset{(22.7602)}{32.1019}\,\Delta x_{10t} + \bar{\bar{u}}_{6t} \qquad \text{(OLS)}$$

$S = 398.9553 \qquad d = 1.79\text{(n)} \qquad R^2 = 0.30$

Ending stocks of soybean meal

$$\Delta y_{9t} = 22.4975\,\Delta_t - \underset{(1.0459)}{1.7683}\,\Delta y_{2t} - \underset{(2.8564)}{2.2255}\,\Delta y_{5t} + \bar{u}_{7t} \qquad \text{(2SLS)}$$

$S = 111.70 \qquad d = 1.98(n)$

$$\Delta y_{9t} = 22.9765\,\Delta_t - \underset{(1.0009)}{1.7087}\,\Delta y_{2t} - \underset{(2.8333)}{2.3513}\,\Delta y_{5t} + \bar{\bar{u}}_{7t} \qquad \text{(OLS)}$$

$S = 111.46 \qquad d = 2.16(n) \qquad R^2 = 0.26$

Handling margin

$$\Delta y_{10t} = 0.1197\,\Delta_t + \underset{(0.1566)}{0.4442}\,\Delta y_{2t} + \underset{(0.4279)}{0.6084}\,\Delta y_{5t} + \bar{u}_{8t} \qquad \text{(2SLS)}$$

$S = 16.73 \qquad d = 2.33(n)$

$$\Delta y_{10t} = 0.0942\,\Delta_t + \underset{(0.1482)}{0.4404}\,\Delta y_{2t} + \underset{(0.4196)}{0.6035}\,\Delta y_{5t} + \bar{\bar{u}}_{8t} \qquad \text{(OLS)}$$

$S = 16.50 \qquad d = 2.42(n) \qquad R^2 = 0.52.$

The identities remain

$$\Delta y_{1t} + \Delta y_{4t} + \Delta y_{5t} = \Delta x_{5t} - \Delta x_{6t}$$

$$\Delta y_{6t} + \Delta y_{8t} + \Delta y_{9t} = \Delta x_{11t}.$$

In general, the results of the estimation process were satisfactory. All structural coefficients exhibit signs consistent with economic theory and evidence. The size of the determination coefficients gives an indication of the importance of the explanatory variables in the different structural relations, except for trend. As noted before, estimation of the model using original values gave R^2 of over 0.9 and highly significant coefficients on time. This indicates that, in general, trends are about of the same importance as the other determinants in the structural equations. Also gratifying is the fact that no serial correlation is indicated in any of the equations, and for those where the Watson-Durbin test was inconclusive, positive rejection of serial correlation is very close.

Starting the discussion of the individual equations with the domestic demand of soybean oil for food, it is seen that all coefficeints display the expected sign. When the coefficients are transformed into elasticities at the mean, a price elasticity of demand of soybean oil for food of − 0.45 and a cross elasticity of demand with respect to the cottonseed oil price of 0.32 are obtained. Under the assumption of a zero income effect, these are elasticities of substitution. The price elasticity of demand obtained here is very different from two other measures obtained by Brandow *(5,* p. 59*)* and Houck *(20,* p. 23*)*. Brandow put the price elasticity of total demand (domestic and foreign) at the wholesale level at − 3.98. Houck obtained a value of about − 2.50. Brandow did not get his estimate from any sophisticated econometric analysis but Houck did. Although the estimates are not strictly comparable because

Houck computed elasticities from price flexibility coefficients, such a difference still demands some explanation. Houck's demand relation must be questioned very seriously. Indeed, the same equation showed a substantial negative relationship between soybean oil demand and income and gave a direct wholesale price elasticity of demand for all vegetable food fats and oils of around -1.25. These measures are in contradiction with experience and theory, and they raise the question of what reliability can be attached to the measure of price elasticity of soybean oil demand. Multicollinearity may have been the cause for these unacceptable values. In the appendix to his work, Houck explicitly states that the complete matrix of all sums of squares and cross products of predetermined variables could not be inverted in the estimation process due to "extremely high intercorrelations" *(20,* p. 62*)*. Furthermore, his elasticity measure refers to domestic demand and foreign demand for oil in oil form. Also, the period of observation combines the immediate postwar years of shortage and a rather insignificant soybean sector with the relatively abundant 1950's and a fast expanding soybean crop that resulted partly because of restrictions on other crops. The defense that a high price elasticity "is as expected since soybean oil, as part of the food fats and oils complex, has several close substitutes" is not very strong *(20,* p. 35*)*. The substitution of animal fats for soybean oil is, from observation, very small (prices of margarine and butter would have to be considerably closer to have a significant substitution possibility), and the closest competing oil, cottonseed oil, has a restricted supply due to allotments on cotton. Finally, experience in recent years indicates that the price elasticity of demand must be considered rather small.

As expected, the coefficient on the soybean oil price in the cottonseed oil price relation and the coefficient on the cottonseed oil price in the domestic demand equation normalized on the soybean oil price are both positive and smaller than one. Consequently, soybean oil, cottonseed oil, and all other food fats and oils are mutual substitutes.

An increase of 1 percent in the soybean oil price will not decrease soybean oil consumption by 0.45 percent. If we also take into account the effect of a 1-percent increase in the soybean oil price on the cottonseed oil price, the actual decrease will only amount to 0.32 percent. The export equation of soybean oil in all forms to Western Europe, Japan, and Canada gave satisfactory results. All signs were in agreement with a priori expectations and this also held for the magnitude of the price elasticity of exports and the elasticity with respect to foreign supplies. The price export elasticity at the means was -0.83 and its computation at the mean of the c.i.f. European port prices gave a value of − 0.90. These measures can be compared with an export elasticity of − 0.79 decided upon by Brandow for soybean oil, cottonseed oil, and lard considered as a group and including the oil contents of exported beans and cottonseed *(5,* p. 6*)*. The estimated equation indicated that a 1-percent increase in important foreign availabilities decreases United States exports of soybean oil by 0.97 percent. Much less is known about the general plausibility of the other two measures obtained in the equation.

The domestic demand equation for soybean meal also gave satisfactory results, and plausible magnitudes were obtained for the elasticities computed at the means. According to the results, a 1-percent increase in other high-protein feed availabilities decreases soybean meal consumption by 0.38 percent; a 1-percent increase in high-protein consuming animal units increases meal consumption by 2.23 percent; a 1-percent increase in livestock prices increases meal consumption by 0.90 percent; and a 1-percent increase in the price of meal decreases consumption by 0.28 percent.

The price elasticity of demand for soybean meal is generally lower than that obtained by other researchers in this field. G. A. King computed elasticities from price flexibility coefficients of − 2.08 and − 1.72 for the interwar and immediate postwar periods, respectively *(22,* p. 113*)*. Suggested price elasticities (again computed from price flexibility coefficients) from a soybean meal analysis published in *The Feed Situation* for the 1946-1957 period were − 1.32 and − 1.30 *(30)*. Houck in his study computed elasticities from price flexibility coefficients of − 0.89 to − 0.93 *(20,* p. 35*)*. Although the price elasticity seems to be decreasing over time, it is very probably true that the coefficients on livestock prices and meal prices must be considered together *(1)*. The present model precludes such a formulation.

The elasticity of soybean meal consumption with respect to livestock prices is somewhat lower than the value obtained by King *(22,* p. 113*)*. The effect of an increase in animal units on soybean meal consumption amounting to 2.23 percent compares favorably with an estimate of 2.00 percent for total concentrates fed, obtained in a recent study *(1)*. The export equation for soybean meal delivered acceptable estimates. A 1-percent increase in the soybean oil price decreased meal exports by 0.70 percent. In the past, soybean oil prices have influenced the exports of meal through bean exports in any given year. This is likely to persist in the future; oil stocks are built up in years of low oil prices, and European and other foreign crushers try to import as much oil as possible under the form of beans. Low meal prices do not seem to lead to a similar phenomenon in the oil sector; introduction of the meal price in the soybean oil export equation led to totally insignificant results. The meal export equation further indicated that a 1-percent increase in European livestock prices increased meal exports by 1.47 percent (a magnitude close to King's estimates for the United States) and a 1-percent increase in the price of soybean meal decreased soybean meal exports by 0.45 percent.[11]

At this point trends in soybean oil and soybean meal demand, both domestic and foreign, will be discussed. The domestic soybean oil demand equation indicated a positive trend of 79,000 metric tons a year and exports of soybean oil showed a positive trend of 42,000 metric tons a year. These trends are a combination of the effect of population increase and outward shifts because of changes in habits. The population in the United States has in recent years been increasing at a rate of about 3 million a year. The cottonseed oil domestic consumption in 1963-64 was 626,000 metric tons and the soybean oil domestic consumption was 1,670,000 metric tons. For cottonseed oil and soybean oil this means a consumption of 2,296,000 metric tons or 12.129 kilograms per capita. Because of acreage allotments on cotton, the cottonseed oil supply is quite stable from year to year. The impact of population increases with respect to soybean oil, and cottonseed oil consumption must, therefore, be borne entirely by soybean oil. For an annual increase of 3 million people, this amounts to 36,000 metric tons of oil. The leftover or 43,000 metric tons represents the annual shift. Because of increasing per capita consumption of soybean and cottonseed oil and an increasing population, this shift is decreasing over time as it should be expected to do. At 1963-64 levels, the shift amounts to 226 grams per capita per year, a not unreasonable magnitude. Assuming that population would increase to 219 million in 1974, under unchanged supply conditions and constant prices consumption of soybean oil would increase 2 kilograms per capita during the 10-year period and the shift decrease to 164 grams per capita (a decrease of 27.5 percent). The same calculation for exports to Western Europe, Japan, and Canada indicates a shift of 77 grams per capita.[12] This trend might actually not decrease, however, because, at least in Western Europe, the resistance against consumption of soybean oil is gradually weakening.

For the meal sector, the respective trends are 335,000 metric tons

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[11] Using the mean of the c.i.f. European port price (± $20), the elasticity is — 0.58.

[12] This rather low magnitude of the shift is in agreement with low income elasticities of demand for vegetable oils and fats and lard as estimated by the EEC Commission. See item *(11)* in Literature Cited.

domestically[13] and 232,000 metric tons with respect to exports. Note, however, that increases in animal units are included in the export trend and excluded from the domestic trend. A question sometimes raised concerns the disequilibrium between the demand for oil and the demand for meal. Of course it only makes sense to talk about a disequilibrium if one or both of the product prices are not free market prices. In this case, the price of meal is essentially a free market price, whereas the price of oil has been consistently supported through P.L. 480 exports. What are the prospects for both markets under this situation? Assuming constant trends in soybean oil consumption for the next 10 years, output would have to be increased by 1,210,000 metric tons because of population increases and shifts. In terms of soybeans, this means an annual increase of 24,200,000 bushels. Assuming, also, that trends continue in the meal sector and high-protein feed animal units in the United States increase by 9 percent (as was the case in the last 10 years), meal output would have to increase by 6,793,000 metric tons. In terms of beans, this is an annual increase of 31,600,000 bushels. At a level of oil prices, as during the last decade, a surplus of 370,000 metric tons of oil would be created over a 10-year period. This is not a large amount. It may easily be absorbed through increased P.L. 480 exports or commercial exports outside Western Europe, Japan, and Canada where, because of the present income levels, the demand for oil is likely to be stronger than the demand for meal. Notice that other exports (about 15 percent of the total) were not included in this analysis. The study also suggests that tariff barriers erected or increased by Western Europe and Japan on either meal or oil would affect exports substantially.

As in the export equations, the price of meal was of no importance in explaining oil stocks, whereas the price of oil influenced the amount of meal in stock. There was a positive relationship between oil stocks and the price of oil, indicating that some stocks are held for speculative purposes. A negative trend in the soybean oil stock equation cannot be accepted. The coefficient on production is, therefore, likely to also be unstructural. Taken together, they might represent the actual structural forces which result in higher stocks as production expands.

A negative trend was expected in the equation explaining the handling margin. Instead, the trend value was very close to zero and the total fluctuation in the margin was attributed to oil and meal price fluctuations. As expected, the influence of the soybean oil price was more pronounced.

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[13] This amounts to a time elasticity of 0.052 and compares with a magnitude of 0.03 for all high-protein feeds found by Ahalt and Egbert. See p. 46 in item *(1)* in Literature Cited.

In general, the OLS estimates and the 2SLS estimates were close. This can be expected when the regressions of the right-hand endogenous variables on the exogenous variables in the system are very good (as was the case here) *(33)*. Indeed, a structural relation of a linear system of equations containing n endogenous variables, r exogenous variables, and n disturbances may be written as

$$y = y_1\gamma_1 + x_1b_1 + u.$$

Theil has noted that there is a whole family of estimators of this structural relation of which 2SLS is a special case *(28,* pp. 231-237*)*. This family, known as the (k) class estimators, is defined by the normal equations:

$$\begin{bmatrix} y'_1y_1 - kv'_1v & y'_1x_1 \\ x'_1y_1 & x'_1x_1 \end{bmatrix} \begin{bmatrix} c(k) \\ b(k) \end{bmatrix} = \begin{bmatrix} y'_1y - kv'_1y \\ x'_1y \end{bmatrix} \qquad \text{(a)}$$

where v_1 is the matrix of residuals from the estimated reduced forms of the right-hand dependent variables. For any choice of k, the normal equations define c(k) and b(k), the (k) estimates of γ_1 and β_1. It is known that if $k = 0$, the expression

$$\begin{bmatrix} y'_1y_1 & y'_1x_1 \\ x'_1y_1 & x'_1x_1 \end{bmatrix} \begin{bmatrix} c(k) \\ b(k) \end{bmatrix} = \begin{bmatrix} y'_1y \\ x'_1y \end{bmatrix} \qquad \text{(b)}$$

gives ordinary least squares estimates. If $k = 1$, 2SLS estimates are obtained, and if $k = 1 + v$, where v is the smallest root of the characteristic equation derived in the maximization of the likelihood function, L.I. estimates are obtained. But no matter what the size of k is, the expression (a) will yield direct least squares estimates on the condition that v_1, the matrix of the residuals, equals zero.

IMPLICATIONS AND CONCLUSIONS

A further check on the estimated model consists of its confrontation with the actual data. There are three sets of unbiased estimates available to do this: (1) the structural 2SLS estimates for every equation; (2) the unrestricted least squares reduced form estimates, where every y_i has been estimated directly from all the x_i; and (3) the 2SLS reduced form estimates, where every y_i is expressed as a function of the x_i, due account being given to the restrictions imbedded in the structural relations. Indeed, every estimated structural relation may be written as

$$y_1 + b_1y_2 \cdots + b_ny_n = a_1x_1 + a_2x_2 \cdots + a_nx_n + 0$$

(where some of the b_i and a_i are zero).

The model, expressed in matrix form, may then be written

$$BY' = AZ' + 0.$$

Algebraic manipulation yields

$$Y' = B^{-1}A^{1}Z.$$

Usually, unrestricted least squares reduced form estimates give the closest fit to the actual data. These estimates are unbiased and are appropriate for forecasting purposes as long as the relationships among the exogenous variables hold. However, they give no structural information and are, therefore, useless from the very moment a structural change is suspected to have taken place. In this case it is possible to fall back on the structural estimates, correct the estimates in the structural equation where the change took place, and recompute the 2SLS reduced form estimates. The structural estimates were given on pages 29 to 31. Below, are given the unrestricted least squares reduced form estimates (ULSRF) and the 2SLS reduced form estimates (2SLSRF) for every endogenous variable:

$$\begin{aligned}\Delta y_{1t} = {} & 173.2733\Delta_t - 1.2744\Delta x_{1t} - 0.6900\Delta x_{2t} - 0.0605\Delta x_{3t} - 0.1405\Delta x_{4t} \\ & - 2.3787\Delta x_{5t} - 0.8868\Delta x_{6t} + 0.4398\Delta x_{7t} - 64.6995\Delta x_{8t} + 4.9831\Delta x_{9t} \\ & - 10.6304\Delta x_{10t} + 0.5689\Delta x_{11t} \qquad \text{(ULSRF)} \\ & S = 116.12 \qquad R^2 = 0.73\end{aligned}$$

$$\begin{aligned}\Delta y_{1t} = {} & 15.5756\Delta_t - 0.0423\Delta x_{1t} - 0.0532\Delta x_{2t} + 0.0692\Delta x_{3t} + 0.1416\Delta x_{4t} \\ & + 0.3943\Delta x_{5t} - 0.1921\Delta x_{6t} + 0.0000\Delta x_{7t} + 0.0000\Delta x_{8t} + 0.0000\Delta x_{9t} \\ & - 4.3675\Delta x_{10t} + 0.0000\Delta x_{11t}{}^{14} \qquad \text{(2SLSRF)}\end{aligned}$$

$$\begin{aligned}\Delta y_{2t} = {} & -9.1946\Delta_t - 0.4222\Delta x_{1t} + 0.0919\Delta x_{2t} + 0.0140\Delta x_{3t} + 0.0694\Delta x_{4t} \\ & + 0.5814\Delta x_{5t} + 0.2792\Delta x_{6t} - 0.1120\Delta x_{7t} + 19.7329\Delta x_{8t} - 1.6186\Delta x_{9t} \\ & + 5.4210\Delta x_{10t} - 0.1801\Delta x_{11t} \qquad \text{(ULSRF)} \\ & S = 21.70 \qquad R^2 = 0.92\end{aligned}$$

$$\begin{aligned}\Delta y_{2t} = {} & 49.5333\Delta_t - 0.0737\Delta x_{1t} - 0.0927\Delta x_{2t} - 0.0559\Delta x_{3t} - 0.1145\Delta x_{4t} \\ & -0.3188\Delta x_{5t} + 0.1553\Delta x_{6t} + 0.0000\Delta x_{7t} + 0.0000\Delta x_{8t} + 0.0000\Delta x_{9t} \\ & + 3.5313\Delta x_{10t} + 0.0000\Delta x_{11t}{}^{14} \qquad \text{(2SLSRF)}\end{aligned}$$

$$\begin{aligned}\Delta y_{3t} = {} & -21.4266\Delta_t - 0.3982\Delta x_{1t} + 0.0256\Delta x_{2t} + 0.0329\Delta x_{3t} + 0.0857\Delta x_{4t} \\ & + 1.0760\Delta x_{5t} + 0.3741\Delta x_{6t} - 0.1917\Delta x_{7t} + 23.5148\Delta x_{8t} - 1.5906\Delta x_{9t} \\ & + 6.4860\Delta x_{10t} - 0.2923\Delta x_{11t} \qquad \text{(ULSRF)} \\ & S = 5.81 \qquad R^2 = 0.99\end{aligned}$$

$$\begin{aligned}\Delta y_{3t} = {} & 29.4071\Delta_t - 0.0471\Delta x_{1t} - 0.1934\Delta_{2t} - 0.0357\Delta x_{3t} - 0.0732\Delta x_{4t} \\ & - 0.2038\Delta x_{5t} + 0.0993\Delta x_{6t} + 0.0000\Delta x_{7t} + 0.0000\Delta x_{8t} + 0.0000\Delta x_{9t} \\ & + 2.2579\Delta x_{10t} + 0.0000\Delta x_{11t}{}^{14} \qquad \text{(2SLSRF)}\end{aligned}$$

$$\begin{aligned}\Delta y_{4t} = {} & -166.46\Delta_t - 0.8519\Delta x_{1t} + 0.4582\Delta x_{2t} + 0.0976\Delta x_{3t} + 0.0442\Delta x_{4t} \\ & + 2.7296\Delta x_{5t} + 0.2319\Delta x_{6t} - 0.2671\Delta x_{7t} + 37.1210\Delta x_{8t} - 4.2272\Delta x_{9t} \\ & + 5.7785\Delta x_{10t} - 0.4431\Delta x_{11t} \qquad \text{(ULSRF)} \\ & S = 23.49 \qquad R^2 = 0.99\end{aligned}$$

$$\begin{aligned}\Delta y_{4t} = {} & -38.7471\Delta_t + 0.1210\Delta x_{1t} + 0.1521\Delta x_{2t} - 0.0095\Delta x_{3t} - 0.0194\Delta x_{4t} \\ & + 0.5230\Delta x_{5t} - 0.2548\Delta x_{6t} + 0.0000\Delta x_{7t} + 0.0000\Delta x_{8t} + 0.0000\Delta x_{9t} \\ & + 0.6004\Delta x_{10t} + 0.0000\Delta x_{11t}{}^{14} \qquad \text{(2SLSRF)}\end{aligned}$$

$$\begin{aligned}\Delta y_{5t} = {} & -4.9067\Delta_t - 0.4152\Delta x_{1t} + 0.2552\Delta x_{2t} - 0.0425\Delta x_{3t} + 0.1030\Delta x_{4t} \\ & + 0.6851\Delta x_{5t} - 0.3053\Delta x_{6t} - 0.1825\Delta x_{7t} + 27.9712\Delta x_{8t} - 0.6124\Delta x_{9t} \\ & + 4.90707\Delta x_{10t} - 0.1379\Delta x_{11t} \qquad \text{(ULSRF)} \\ & S = 105.80 \qquad R^2 = 0.64\end{aligned}$$

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[14] The first significant digit of the coefficients on x_7, x_8, and x_9 was of the order of magnitude of 10^{-6} to 10^{-8}.

$$\Delta y_{5t} = 23.1715\Delta_t - 0.0787\Delta x_{1t} - 0.0989\Delta x_{2t} - 0.0597\Delta x_{3t} - 0.1221\Delta x_{4t} + 0.0826\Delta x_{5t} - 0.5530\Delta x_{6t} + 0.0000\Delta x_{7t} + 0.0000\Delta x_{8t} + 0.0000\Delta x_{9t} + 3.6771\Delta x_{10t} + 0.0000\Delta x_{11t}{}^{14} \quad \text{(2SLSRF)}$$

$$\Delta y_{6t} = 5.1220\Delta_t + 0.0489\Delta x_{1t} + 0.0418\Delta x_{2t} - 0.0055\Delta x_{3t} + 0.0156\Delta x_{4t} - 0.0728\Delta x_{5t} + 0.0104\Delta x_{6t} + 0.0254\Delta x_{7t} - 2.7864\Delta x_{8t} + 0.6231\Delta x_{9t} - 0.1897\Delta x_{10t} + 0.0148\Delta x_{11t} \quad \text{(ULSRF)}$$

$S = 2.30 \qquad R^2 = 0.99$

$$\Delta y_{6t} = 4.7739\Delta_t + 0.0140\Delta x_{1t} + 0.0176\Delta x_{2t} + 0.0106\Delta x_{3t} + 0.0217\Delta x_{4t} + 0.0606\Delta x_{5t} - 0.0295\Delta x_{6t} - 0.0100\Delta x_{7t} + 2.4954\Delta x_{8t} + 0.5312\Delta x_{9t} + 0.0961\Delta x_{10t} - 0.0240\Delta x_{11t} \quad \text{(2SLSRF)}$$

$$\Delta y_{7t} = 381.83\Delta_t - 0.6549\Delta x_{1t} + 0.2514\Delta_{2t} - 0.0597\Delta x_{3t} + 0.5458\Delta x_{4t} + 0.8434\Delta x_{5t} + 4.7598\Delta x_{6t} - 1.1382\Delta x_{7t} + 139.6604\Delta x_{8t} + 12.3242\Delta x_{9t} + 1.4010\Delta x_{10t} - 0.3886\Delta x_{11t} \quad \text{(ULSRF)}$$

$$\Delta y_{7t} = 213.0082\Delta_t - 0.3592\Delta x_{1t} - 0.4517\Delta x_{2t} - 0.2725\Delta x_{3t} - 0.5576\Delta x_{4t} - 1.5525\Delta x_{5t} + 0.7664\Delta x_{6t} - 0.1598\Delta x_{7t} + 39.8476\Delta x_{8t} + 8.4821\Delta x_{9t} - 2.4616\Delta x_{10t} + 0.6158\Delta x_{11t} \quad \text{(2SLSRF)}$$

$$\Delta y_{8t} = -368.3709\Delta_t - 0.7099\Delta x_{1t} + 1.0854\Delta x_{2t} + 0.14299\Delta x_{3t} + 0.1105\Delta x_{4t} + 3.5470\Delta x_{5t} - 1.1992\Delta x_{6t} + 0.0708\Delta x_{7t} - 15.4690\Delta x_{8t} - 14.1088\Delta x_{9t} + 17.4412\Delta x_{10t} + 0.0184\Delta x_{11t} \quad \text{(ULSRF)}$$

$S = 236.41 \qquad R^2 = 0.95$

$$\Delta y_{8t} = -137.2914\Delta_t + 0.2600\Delta x_{1t} + 0.3269\Delta x_{2t} + 0.1972\Delta x_{3t} + 0.4036\Delta x_{4t} + 1.1237\Delta x_{5t} - 0.5475\Delta x_{6t} + 0.1375\Delta x_{7t} - 34.2938\Delta x_{8t} - 7.2999\Delta x_{9t} + 8.9201\Delta x_{10t} + 0.3305\Delta x_{11t} \quad \text{(2SLSRF)}$$

$$\Delta y_{9t} = -13.4619\Delta_t + 1.3648\Delta x_{1t} - 1.3369\Delta x_{2t} - 0.0832\Delta x_{3t} - 0.6564\Delta x_{4t} - 4.3906\Delta x_{5t} - 3.5604\Delta x_{6t} + 1.0674\Delta x_{7t} - 124.1929\Delta x_{8t} + 1.7846\Delta x_{9t} - 18.8425\Delta x_{10t} + 1.3701\Delta x_{11t} \quad \text{(ULSRF)}$$

$S = 93.13 \qquad R^2 = 0.91$

$$\Delta y_{9t} = -75.71699\Delta_t + 0.0992\Delta x_{1t} + 0.1247\Delta x_{2t} + 0.0752\Delta x_{3t} + 0.1540\Delta_{4t} + 0.4288\Delta x_{5t} - 0.2089\Delta x_{6t} + 0.0222\Delta x_{7t} - 5.5538\Delta x_{8t} - 1.1822\Delta x_{9t} - 6.4585\Delta x_{10t} + 0.0535\Delta x_{11t} \quad \text{(2SLSRF)}$$

$$\Delta y_{10t} = 20.83\Delta_t - 0.0842\Delta x_{1t} + 0.0834\Delta x_{2t} - 0.0355\Delta x_{3t} - 0.0152\Delta x_{4t} - 0.0519\Delta x_{5t} + 0.1129\Delta x_{6t} + 0.0162\Delta x_{7t} + 1.3510\Delta x_{8t} + 0.5896\Delta x_{9t} - 0.1266\Delta x_{10t} - 0.0169\Delta x_{11t} \quad \text{(ULSRF)}$$

$S = 13.96 \qquad R^2 = 0.93$

$$\Delta y_{10t} = 25.0318\Delta_t - 0.0242\Delta x_{1t} - 0.0304\Delta x_{2t} - 0.0183\Delta x_{3t} - 0.0376\Delta x_{4t} - 0.1047\Delta x_{5t} - 0.0510\Delta x_{6t} - 0.0060\Delta x_{7t} + 1.5184\Delta x_{8t} + 0.3232\Delta x_{9t} + 1.6274\Delta x_{10t} - 0.0146\Delta x_{11t}. \quad \text{(2SLSRF)}$$

Looking at the demands for soybean oil (domestic demand, foreign demand, and stock demand) and the soybean oil price, ULSRF indicated correctly 23 out of 28 changes of direction; the performance of 2SLSRF was identical — 23 correct indications out of 28 changes. With respect to the total number of differences, ULSRF indicated the sign of the change correctly in 49 out of 56 cases. Only three errors were registered in the stock demand relation, and 2SLSRF failed to indicate the right sign of the difference 5 times out of a possible total of 56. ULSRF were generally better in predicting the magnitude of the difference. Table 7 shows the actual differences and their predictions by various methods for the three demands of soybean oil and the soybean oil price.

2SLSRF performed much less satisfactorily in the meal sector than ULSRF. The latter indicated all changes of direction correctly, except for two in the stock relation for soybean meal, and failed to indicate the right sign on the difference only 4 times out of a possible 56 (3 of which occurred in the stock relation). Predicted differences were furthermore close to actual ones. 2SLSRF was wrong 6 times in indicating the direction (out of 27) and missed the sign on the difference in 13 cases out of 56 (mostly responsible for this were the stock relation — 5 errors — and some small deviations in the prediction of the soybean meal price which were, however, large enough to carry a different sign). Table 8 shows the actual and predicted differences for the three demands of soybean meal and the soybean meal price. The structural model, reflected in the 2SLSRF, was used to evaluate shifts in various exogenous variables and trace their effects on the jointly determined variables of the system. First, the effect of the elimination of the P.L. 480 program in soybean oil was studied. That program now amounts to about 300,000 metric tons of oil. Its elimination was found to decrease the soybean oil price by $47 per metric ton or 2.14 cents per pound. The cottonseed oil price would drop by 1.36 cents per pound. The effects on the quantities of oil and meal demanded and stored can be found in Table 9. It is also interesting to see the effects of a given decrease in the supply of beans. A decrease of 10 million bushels of beans (or 50,000 metric tons of oil or 214,000 metric tons of meal) would increase the price of oil by 0.7 cents a pound. Note that a decrease in the supply of beans is taken here as a decrease in x_5 and x_{11} and that these variables also include starting stocks. Also, then, an increase of 50,000 metric tons of commercial oil exports outside Western Europe, Japan, and Canada would raise the soybean oil price by 0.7 cents a pound. It is worth noting that a change in the supply not originating in P.L. 480 exports has a greater effect than the same change coming through P.L. 480 exports. Indeed, a change in supply of 300,000 metric tons would affect the price by 4.32 cents per pound. The same change in P.L. 480 quantities has an effect on price of 2.14 cents per pound. This is reasonable as P.L. 480 exports very probably affect commercial exports to some degree.

Another hypothetical situation that can be examined is the influence of trends when all other exogenous variables are unchanged. Some results are: an increase of the soybean oil price by 2.25 cents per pound; an increase in domestic oil and meal demand, but decreases in their exports; and an increase in the price of soybean meal. The trends in domestic and foreign demand for soybean oil and soybean meal have been discussed earlier. What does the whole system indicate with re-

Table 7.—Actual and Predicted Differences in Soybean Oil Price, Consumption, Exports (All Forms), and Stocks (All Forms) for Marketing Years (Beginning October 1) 1949-1964

Years (first pair minus second pair)	Differences			
	Actual	Predicted from		
		2-stage least-squares structural estimates	2-stage least-squares reduced form estimates	Unrestricted least-squares reduced form estimates
Soybean oil price (dollars per metric ton)				
1949-50 – 1948-49	−32	...	−38	−39
1951-52 – 1949-50	−8	...	−40	−18
1952-53 – 1951-52	18	...	2	10
1953-54 – 1952-53	31	...	45	31
1954-55 – 1953-54	−35	...	−7	−34
1955-56 – 1954-55	13	...	58	6
1956-57 – 1955-56	4	...	8	1
1957-58 – 1956-57	−42	...	−2	−32
1958-59 – 1957-58	−29	...	−31	−26
1959-60 – 1958-59	−26	...	−52	−34
1960-61 – 1959-60	66	...	40	64
1961-62 – 1960-61	−40	...	−76	−32
1962-63 – 1961-62	−13	...	−27	−9
1963-64 – 1962-63	−9	...	12	11
Domestic soybean oil consumption for food (thousands of metric tons)				
1949-50 – 1948-49	67	66	86	123
1951-52 – 1949-50	208	127	148	218
1952-53 – 1951-52	132	97	116	155
1953-54 – 1952-53	−34	−2	−37	−59
1954-55 – 1953-54	120	115	66	84
1955-56 – 1954-55	−32	52	−4	34
1956-57 – 1955-56	15	111	102	26
1957-58 – 1956-57	226	163	121	205
1958-59 – 1957-58	107	65	102	47
1959-60 – 1958-59	19	98	104	50
1960-61 – 1959-60	−5	6	30	16
1961-62 – 1960-61	87	153	171	82
1962-63 – 1961-62	27	41	84	58
1963-64 – 1962-63	198	41	52	95

Years (first pair minus second pair)	Differences			
	Actual	Predicted from		
		2-stage least-squares structural estimates	2-stage least-squares reduced form estimates	Unrestricted least-squares reduced form estimates
Soybean oil exports, all forms (thousands of metric tons)				
1949-50 – 1948-49	−64	−14	−14	−70
1951-52 – 1949-50	7	38	74	−5
1952-53 – 1951-52	−22	−31	−18	−30
1953-54 – 1952-53	54	22	0	54
1954-55 – 1953-54	76	147	102	78
1955-56 – 1954-55	89	142	56	81
1956-57 – 1955-56	106	47	35	102
1957-58 – 1956-57	−62	61	12	−50
1958-59 – 1957-58	121	116	124	122
1959-60 – 1958-59	196	85	113	187
1960-61 – 1959-60	−76	−76	−36	−78
1961-62 – 1960-61	250	83	155	259
1962-63 – 1961-62	75	95	125	81
1963-64 – 1962-63	−52	−15	−17	−31
Soybean oil stocks, all forms (thousands of metric tons)				
1949-50 – 1948-49	−1	−70	−69	−52
1951-52 – 1949-50	43	58	37	43
1952-53 – 1951-52	13	33	24	−4
1953-54 – 1952-53	−55	−11	3	−30
1954-55 – 1953-54	33	31	60	68
1955-56 – 1954-55	23	−28	28	−38
1956-57 – 1955-56	32	9	17	24
1957-58 – 1956-57	10	9	41	21
1958-59 – 1957-58	−5	2	−3	55
1959-60 – 1958-59	50	65	47	26
1960-61 – 1959-60	130	80	54	110
1961-62 – 1960-61	−21	37	−10	−23
1962-63 – 1961-62	169	80	61	132
1963-64 – 1962-63	−115	7	8	−28

Table 8.—Actual and Predicted Differences in Soybean Meal Price, Consumption, Exports (All Forms), and Stocks (All Forms) for Marketing Years (Beginning October 1) 1949-1964

Years (first pair minus second pair)	Differences: Actual	Predicted from: 2-stage least-squares structural estimates	Predicted from: 2-stage least-squares reduced form estimates	Predicted from: Unrestricted least-squares reduced form estimates
Soybean meal price (dollars per metric ton)				
1949-50 – 1948-49	−2	...	10	−1
1951-52 – 1949-50	21	...	36	22
1952-53 – 1951-52	−17	...	−23	−17
1953-54 – 1952-53	12	...	2	12
1954-55 – 1953-54	−20	...	−15	−20
1955-56 – 1954-55	−9	...	−16	−8
1956-57 – 1955-56	−6	...	−10	−5
1957-58 – 1956-57	7	...	16	6
1958-59 – 1957-58	3	...	−11	2
1959-60 – 1958-59	0	...	−1	1
1960-61 – 1959-60	6	...	21	6
1961-62 – 1960-61	3	...	−5	3
1962-63 – 1961-62	8	...	−2	8
1963-64 – 1962-63	0	...	4	−3
Domestic soybean meal consumption for food (thousands of metric tons)				
1949-50 – 1948-49	331	285	−12	258
1951-52 – 1949-50	1,023	1,023	653	908
1952-53 – 1951-52	−118	−376	−198	−199
1953-54 – 1952-53	−495	−581	−325	−493
1954-55 – 1953-54	421	635	494	439
1955-56 – 1954-55	556	447	682	473
1956-57 – 1955-56	956	706	826	918
1957-58 – 1956-57	789	899	621	899
1958-59 – 1957-58	886	554	899	911
1959-60 – 1958-59	−444	−147	−104	−531
1960-61 – 1959-60	352	478	103	331
1961-62 – 1960-61	359	192	381	440
1962-63 – 1961-62	294	281	537	342
1963-64 – 1962-63	−385	99	−69	−169

Years (first pair minus second pair)	Differences: Actual	Predicted from: 2-stage least-squares structural estimates	Predicted from: 2-stage least-squares reduced form estimates	Predicted from: Unrestricted least-squares reduced form estimates
Soybean meal exports, all forms (thousands of metric tons)				
1949-50 – 1948-49	−318	134	−28	−217
1951-52 – 1949-50	48	501	436	114
1952-53 – 1951-52	230	237	382	296
1953-54 – 1952-53	261	−84	−31	230
1954-55 – 1953-54	571	692	451	519
1955-56 – 1954-55	280	485	274	399
1956-57 – 1955-56	345	395	415	377
1957-58 – 1956-57	−218	340	8	−294
1958-59 – 1957-58	708	324	540	623
1959-60 – 1958-59	749	379	509	828
1960-61 – 1959-60	−295	−67	−118	−260
1961-62 – 1960-61	997	465	835	953
1962-63 – 1961-62	812	446	699	828
1963-64 – 1962-63	345	266	164	118
Soybean meal stocks, all forms (thousands of metric tons)				
1949-50 – 1948-49	14	93	67	−15
1951-52 – 1949-50	30	6	13	79
1952-53 – 1951-52	143	42	71	158
1953-54 – 1952-53	−183	−59	−61	−154
1954-55 – 1953-54	20	126	66	53
1955-56 – 1954-55	76	30	−44	39
1956-57 – 1955-56	−30	33	30	−22
1957-58 – 1956-57	47	66	−11	14
1958-59 – 1957-58	−51	65	103	10
1959-60 – 1958-59	217	82	117	225
1960-61 – 1959-60	−165	−104	−93	−179
1961-62 – 1960-61	27	73	166	−11
1962-63 – 1961-62	205	19	75	142
1963-64 – 1962-63	132	8	−8	143

spect to necessary increases in the supply of oil (x_5) and of meal (x_{11}) to keep prices constant through time? Increases in human and animal population shifts in meal and oil consumption and trends in stocks define these magnitudes. The result is an annual increase of 31 million bushels to cover oil needs and 34 million bushels to cover meal needs. More hypothetical situations could be set up and their impact traced through the system. A sample of such situations has been summarized in Table 9.

The most important points brought out by the investigation may be summarized as follows. First of all, it is evident that trends in the demands for oil and meal, both domestic and foreign, are strong. But this does not mean that prices are not important. Elasticities are generally low with price elasticities for export demand higher than for domestic demand, both for oil and meal. The interdependence between meal and oil sectors lies in the export and stock relationship. The hypothesis that the price of meal is an important determinant in the exports and storage of soybean oil was rejected. On the other hand, the price of oil seemed to play a role in meal exports and storage, although that indication was not very strong. Meal export and storage functions were the weaker relationships in the model. It is probably true that the meal export relationship had no unique identity during the 1950's and that meal exports were to a considerable degree dependent on oil exports. With rising incomes and increasing demand for meat products, this relationship may become more clearly defined as time progresses. In much the same way, it was difficult to clearly isolate determinants for the demand for meal storage.

The model points out the need for a substantial continued increase in soybean supplies. This annual increase lies in the neighborhood of 30 million bushels. If this increase does not occur, fast-rising oil prices that would very probably stimulate stagnating foreign production may be expected. It may also be expected that meal prices would be checked by feed grain prices and supplies of artificial high-protein feeds. As acreage cannot indefinitely expand, the need for higher yields per acre becomes crucial.

At supported prices, the disappearance of oil has been a problem in the past. The model indicates, however, that at prevailing supported oil prices this problem would not become more difficult. This is confirmed by the experience of the last five to seven years. In fact, some trade expansion with nations of Eastern Europe, for example, might erase the problem altogether. The model also indicates that since the establishment of P.L. 480, soybean oil prices have been supported at a rate of 2.5 cents per pound.

Table 9. — The Effect of Specified Changes on the 10-Endogenous Variables of the Soybean Oil and Soybean Meal Markets Using Estimated Structural Coefficients[a]

Specified change	Effect on price of:			Effect on margin	Effect on demand for:					
	Oil	Meal	Cotton-seed oil		Domestic oil	Foreign oil	Domestic meal	Foreign meal	Oil stocks	Meal stocks
	dollars per metric ton			*cents per bushel*	*1,000 metric tons*					
Drop of 300,000 metric tons of soybean oil under P. L. 480	−47.0	8.80	−30.0	−15.0	58.0	76.0	−227.0	164.0	166.0	63.0
Drop of 100,000 metric tons of cottonseed oil under P. L. 480	−9.0	1.70	−19.0	−3.0	−5.3	15.0	−45.0	32.0	−9.0	13.0
Decrease in supply of 10 million bushels (50,000 metric tons of oil and 214,000 metric tons of meal)	16.0	2.10	10.0	8.3	−20.0	−26.0	−55.0	−126.0	−4.0	−33.0
Pure trend effect (no changes in exogenous variables) per marketing period	49.0	4.77	29.4	25.0	16.0	−38.0	213.0	−137.0	22.0	−76.0
Increase in foreign supplies of 500,000 metric tons (in the same proportion for the different fats and oils as the composition of x_3)	−28.0	5.30	−18.0	−9.2	35.0	−5.0	−136.0	99.0	−30.0	37.0

[a] Absence of government intervention assumed.

Appendix Table 1. — October-September Simple Averages of Monthly C.I.F. Quotations, European Ports, of the Most Important Internationally Traded Fats and Oils, 1949-1961

Year beginning October 1[a]	Soybean oil	Cotton-seed oil	Coconut oil	Palm-kernel oil	Palm oil	Ground-nut oil	Lard
			dollars per metric ton				
1949	303	332	338	351	238	402	269
1950	422	474	436	423	413	523	426
1951	285	345	280	255	247	407	316
1952	295	357	318	282	207	379	283
1953	323	278	314	281	212	397	424
1954	280	245	264	239	223	293	322
1955	304	326	251	235	243	352	293
1956	300	331	255	238	250	380	344
1957	260	([b])	283	255	230	295	319
1958	219	232	363	334	234	291	262
1959	193	237	327	317	228	324	254
1960	268	306	247	247	225	331	301
1961	220	([b])	230	221	219	287	256

[a] For the marketing year 1949-50, the prices of January, 1950-June, 1950, were taken. Formerly, prices were not quoted, and after June they were disrupted by the Korean War. Some adaptations occurred to keep the prices on a uniform basis (e.g., addition of $20 per metric ton for the transportation in drums versus transportation in bulk).
[b] No data available.
Source: *(14)*.

Appendix Table 2. — Supply and Disposition of Soybeans in the United States, 1947-1964

Year[a]	Gross product	Net product[b]	Beginning stocks, all positions	Crushing	Exports	Feed, seed, and residual	Ending stocks, all positions
				million bushels			
1947-48	186.5	186.5	5.4	161.4	2.9	24.9	2.6
1948-49	227.2	227.2	2.6	183.7	23.0	19.9	3.2
1949-50	234.2	234.2	3.2	195.3	13.1	26.0	2.9
1950-51	299.3	299.3	2.9	252.0	27.8	18.0	4.2
1951-52	283.8	283.8	4.2	244.3	17.0	22.9	3.6
1952-53	298.8	298.8	3.6	234.4	31.9	26.0	10.1
1953-54	269.2	269.2	10.1	213.2	39.7	25.1	1.3
1954-55	341.1	341.1	1.3	249.0	60.6	22.9	9.9
1955-56	373.7	368.2	9.9	283.1	67.5	29.3	3.7
1956-57	449.3	448.8	3.7	316.0	85.4	41.2	9.9
1957-58	483.4	483.4	9.9	353.8	85.5	32.9	21.1
1958-59	580.2	483.7	21.1	401.2	110.1	31.4	62.1
1959-60	532.9	530.9	62.1	393.2	141.4	35.0	23.2
1960-61	555.3	554.3	23.2	402.2	130.1	39.2	6.0
1961-62	679.6	691.1	6.0	438.8	153.2	47.5	57.0
1962-63	669.2	658.7	57.0	474.5	180.3	46.4	15.1
1963-64	699.4	699.4	15.1	440.9	191.1	50.4	32.0

[a] Beginning October 1.
[b] After correction for part of current crop crushed and exported before October 1.
Source: *(31)*.

Appendix Table 3. — Supply and Disposition of Soybean Oil in the United States, 1947-1964

Year[a]	Crushing: Yield	Crushing: Product	Beginning stocks	Total supply	Domestic dis-appearance	Exports of oil	Ending stocks
	pounds per bushel			*million pounds*			
1947-48	9.5	1,534	204	1,738	1,532	112	96
1948-49	9.8	1,807	96	1,903	1,488	300	113
1949-50	9.9	1,937	113	2,050	1,646	291	113
1950-51	9.7	2,545	113	2,567	1,906	490	171
1951-52	10.0	2,444	171	2,615	2,150	271	194
1952-53	10.8	2,536	194	2,730	2,462	73	174
1953-54	11.0	2,350	174	2,525	2,326	71	127
1954-55	10.9	2,711	127	2,838	2,609	50	179
1955-56	11.1	3,143	179	3,322	2,539	556	227
1956-57	10.9	3,431	227	2,658	3,565	807	286
1957-58	10.7	3,800	286	4,085	3,051	804	287
1958-59	10.6	4,251	281	4,532	3,304	930	298
1959-60	11.0	4,338	298	4,636	3,376	953	308
1960-61	11.0	4,420	308	4,728	3,329	721	677
1961-62	10.9	4,790	677	5,467	3,540	1,308	618
1962-63	10.7	5,091	618	5,709	3,624	1,165	920
1963-64	11.0	4,822	920	5,742	4,060	1,104	578

[a] Beginning October 1.
Source: *(31)*.

Appendix Table 4. — Commercial Availability of Soybean Oil (All Forms) in the United States, 1947-1964

Year[a]	Oil supply	Bean exports, oil equivalent	Ending stocks of beans, all positions	Total	CCC stocks (plus reseal)	CCC operations (CCC plus reseal)[b]	P. L. 480	Total noncommercial	Net commercial
				million pounds					
1947-48	1,738	27	25	1,790	0	0	0	0	1,790
1948-49	1,903	225	31	2,159	0	0	0	0	2,159
1949-50	2,050	128	28	2,206	0	0	0	0	2,206
1950-51	2,567	272	41	2,880	0	0	0	0	2,880
1951-52	2,615	167	36	2,818	0	0	0	0	2,818
1952-53	2,730	320	109	3,159	0	22	0	22	3,137
1953-54	2,525	436	114	2,975	22	−22	0	0	2,975
1954-55	2,838	666	108	3,612	0	74	0	74	3,538
1955-56	3,322	741	41	4,104	74	−74	286	286	3,818
1956-57	3,658	937	109	4,704	0	56	485	541	4,163
1957-58	4,085	939	226	5,255	56	93	492	641	4,609
1958-59	4,532	1,209	661	6,402	149	463	746	1,232	5,044
1959-60	4,636	1,552	251	6,444	612	−510	596	703	5,741
1960-61	4,728	1,431	66	6,225	102	−102	441	441	5,784
1961-62	5,467	1,685	634	7,786	0	555	686	1,114	6,545
1962-63	5,709	1,984	166	7,859	555	−537	647	666	7,193
1963-64	5,742	2,102	352	8,196	18	98	601	601	7,478

[a] Beginning October 1.
[b] Positive values for operations whose effect is to decrease the supply of oil and (—) for operations whose effect is to increase the supply.
Source: *(31)*.

Appendix Table 5. — Net Commercial Supply of Soybean Oil for Food in the United States, 1947-1964

Year[a]	Net commercial supply	Nonfood use, domestic	Commercial supply for food
		1,000 metric tons	
1947-48	812.7	124	688.7
1948-49	980.2	140	840.2
1949-50	1,001.5	144	857.5
1950-51	1,307.5	140	1,167.5
1951-52	1,274.4	165	1,114.4
1952-53	1,424.2	175	1,249.2
1953-54	1,350.7	147	1,203.7
1954-55	1,606.3	156	1,450.3
1955-56	1,733.4	156	1,577.4
1956-57	1,890.0	153	1,737.0
1957-58	2,095.0	148	1,947.7
1958-59	2,292.7	156	2,136.7
1959-60	2,606.4	170	2,436.4
1960-61	2,625.9	154	2,471.9
1961-62	2,975.0	163	2,812.0
1962-63	3,265.6	174	3,091.6
1963-64	3,399.0	174	3,225.0

[a] Beginning October 1.

Appendix Table 6. — Cottonseed Oil Supply and Disappearance in the United States, 1947-1964

Marketing year[a]	Production	Seed stocks, oil equivalent	Commercial stocks	CCC operations[b]	P. L. 480	Total commercial supply available for domestic market	Domestic disappearance
				1,000 metric tons of oil			
1947-48	666	15	85	0	0	766	597
1948-49	865	13	55	0	0	933	708
1949-50	963	19	84	0	0	1,066	759
1950-51	599	43	98	0	0	740	538
1951-52	914	10	76	−62	0	938	634
1952-53	923	20	120	−351	0	712	545
1953-54	1,018	22	28	7	0	1,075	771
1954-55	859	34	68	76	0	1,037	750
1955-56	931	31	181	6	113	1,036	625
1956-57	836	26	129	0	25	966	606
1957-58	710	24	92	0	44	782	538
1958-59	746	25	91	0	64	798	514
1959-60	923	14	97	0	43	991	574
1960-61	906	16	131	0	38	1,015	662
1961-62	915	29	114	0	131	927	650
1962-63	939	43	147	0	82	1,047	628
1963-64	948	36	234	0	115	1,103	626

[a] Beginning August 1.
[b] CCC sales were 28,000, 305,000, and 25,000 metric tons, respectively, in 1953-54, 1954-55, and 1955-56. However, according to contemporaneous issues of *(31)*, only around 25 percent was sold in the domestic market. The rest was sold abroad at lower prices. Also, P.L. 480 sales were 55,000 and 132,000 metric tons, respectively, in 1954-55 and 1955-56. It was assumed that 75 percent of the amount sold by the CCC in those years contributed to the P.L. 480 program.
Source: *(31)*.

Appendix Table 7. — Supply and Disappearance of Edible Lard and Butter in the United States, 1947-1964

Marketing year[a]	Butter: Supply (production and stocks)	Butter: Domestic disappearance	Lard: Supply (production and stocks)	Lard: Domestic disappearance	Lard and butter supply
	1,000 metric tons				
1947-48	577	530	923	889	1,500
1948-49	669	595	1,013	869	1,682
1949-50	723	612	1,076	919	1,799
1950-51	661	590	1,176	993	1,837
1951-52	577	525	1,223	941	1,800
1952-53	677	524	1,093	959	1,770
1953-54	812	570	941	806	1,753
1954-55	843	623	1,077	890	1,940
1955-56	779	627	1,230	939	2,009
1956-57	678	606	1,159	931	1,837
1957-58	702	620	1,052	906	1,754
1958-59	672	622	1,164	920	1,836
1959-60	665	594	1,204	911	1,869
1960-61	714	602	1,108	894	1,822
1961-62	814	616	1,112	909	1,926
1962-63	852	589	1,120	823	1,972
1963-64	850	620	1,122	769	1,972

[a] Beginning October 1.
Source: *(31)*.

Appendix Table 8. — Production of Oilseeds and Animal Fats and Oils in Japan, 1947-1964

Year (t)[a]	Whale oil	Soybean oil	Rapeseed oil	Sesame seed oil	Groundnut oil	Total
	1,000 metric tons of oil					
1947	14	37	2	1	2	56
1948	21	33	5	1	2	62
1949	23	40	9	1	3	76
1950	33	39	14	1	3	90
1951	35	80	42	2	6	165
1952	52	85	63	3	7	210
1953	46	94	99	3	12	254
1954	66	77	101	2	14	260
1955	87	68	77	2	14	248
1956	102	91	95	3	16	307
1957	117	82	112	3	17	331
1958	142	83	100	2	25	352
1959	146	70	93	2	29	340
1960	139	77	92	2	33	343
1961	147	75	92	2	44	360
1962	166	70	96	2	50	384
1963	173	60	86	1	50	370
1964	170	57	38	2	50	317

[a] The year (t) refers to the harvest late in the preceding year which usually becomes available for consumption in year (t).
Sources: Whale oil, *(29)*; other oils, *(15)*.

Appendix Table 9. — Production of Oilseeds and Oils in Western Europe, 1946-1964

Year (t)[a]	Soybean oil	Cottonseed oil	Sunflower seed oil	Sesame seed oil	Groundnut oil	Olive oil	Rapeseed oil	Whale oil	Total
					1,000 metric tons				
1946	0	6	4	4	5	390	57	144	610
1947	0	6	4	4	5	647	57	286	1,009
1948	1	6	4	5	8	1,026	46	305	1,401
1949	1	6	4	4	8	326	95	330	774
1950	0	6	4	4	8	925	170	319	1,436
1951	0	10	3	5	8	429	156	328	939
1952	0	13	4	5	8	1,329	181	308	1,848
1953	0	12	4	4	9	640	193	249	1,111
1954	0	17	3	7	8	999	98	291	1,423
1955	0	23	3	6	9	771	116	246	1,174
1956	0	36	3	7	9	629	114	253	1,051
1957	0	35	4	5	9	826	72	262	1,213
1958	0	32	3	5	8	977	164	244	1,433
1959	0	35	4	4	9	771	152	222	1,197
1960	0	41	4	6	9	1,003	146	197	1,406
1961	0	44	5	5	9	1,064	90	210	1,427
1962	0	62	5	5	9	1,172	131	158	1,542
1963	0	62	8	4	10	777	182	74	1,117
1964	0	60	13	6	9	1,562	142	59	1,851

[a] The year (t) refers to the harvest late in the preceding year which usually becomes available for consumption in year (t).
Sources: Whale oil, *(29)*; other oils, *(15)*.

Appendix Table 10. — Consumption of High-Protein Feeds and Milk per Animal Unit, European Countries, 1955-1959

Calendar Year[a]	Animal[b]	United Kingdom	Western Germany	France	Netherlands	Belgium	Denmark
				kilograms			
1955	Cows	101	26	22	58	60	77
	Hogs	105	67	109	124	165	137
	Chickens	525	258	107	447	350	588
1957	Cows	91	36	22	77	61	81
	Hogs	102	74	113	142	179	113
	Chickens	487	308	110	475	328	597
1958	Cows	104	47	26	80	75	88
	Hogs	103	84	115	156	193	119
	Chickens	498	326	127	477	406	542
1959	Cows	121	59	98	92	77	119
	Hogs	127	95	122	172	190	123
	Chickens	528	380	133	486	409	708

[a] Data for 1956 not available.
[b] 1 cow = 1.000 animal unit; 1 hog = 0.200 animal unit; and 1 chicken = 0.004 animal unit.
Source: *(25)*.

Appendix Table 11.—Supply of Groundnut Oil of Nigeria and French West Africa, 1948-1964

Year (t)[a]	Production									Nigerian stocks		Total
	Nigeria	French West Africa										
		All[b]	Dahomey	Guinea	Ivory Coast	Mali	Niger	Senegal	Upper Volta			
	1,000 metric tons, unshelled basis									*1,000 long tons, shelled basis*	*1,000 metric tons, oil equivalent*	*1,000 metric tons, oil equivalent*
1948	560	748								92	42	450
1949	560	836								155	71	560
1950	463	850								137	63	523
1951	430	704								0	0	397
1952	860	877								5	2	610
1953	875	841								129	59	660
1954	870	895								196	90	708
1955	790	794								135	62	616
1956	1,000	938								7	3	681
1957	770	1,150								19	9	681
1958	1,300	1,350								3	1	929
1959	1,025		16	26	22	123	168	765	50	142	65	833
1960	900		14	25	25	120	104	832	70	29	13	745
1961	1,150		18	26	24	125	150	892	95	26	12	880
1962	1,245		22	27	20	110	152	995	110	37	17	955
1963	1,515		20	20	29	104	205	900	113	34	16	1,028
1964	1,393		31	20	31	118	220	953	129	132	62	1,075

[a] The year (t) refers to the harvest late in the preceding year which usually becomes available for consumption in year (t).
[b] For 1948-1958, only total data available.
Sources: Nigerian stocks, *(6)*; other, *(15)*.

Appendix Table 12. — Production of Palm Oil of Nigeria, Republic of the Congo, and Indonesia, 1947-1963

Year	Nigeria	Republic of the Congo (Leopoldville)	Indonesia	Total
		1,000 metric tons		
1947	137	134	1	272
1948	147	153	56	356
1949	172	160	117	449
1950	167	178	124	469
1951	145	197	119	461
1952	190	165	144	499
1953	224	177	158	559
1954	217	191	166	574
1955	198	194	163	555
1956	191	217	162	570
1957	171	230	158	559
1958	184	222	145	551
1959	190	241	135	566
1960	189	230	139	558
1961	173	220	143	536
1962	130	225	139	494
1963	149	220	146	515

Source: *(6)*.

Appendix Table 13. — Production of Palm Kernel and Palm Kernel Oil of Nigeria, French West Africa, and Republic of the Congo, 1947-1963

Year	Nigeria	French West Africa					Republic of the Congo (Leopoldville)	Total oil equivalent
		All[a]	Dahomey	Guinea	Ivory Coast	Senegal		
				1,000 long tons				*1,000 metric tons*
1947	328	39					84	206
1948	355	62					110	241
1949	373	85					87	249
1950	381	90					128	274
1951	330	67					134	243
1952	413	64					108	267
1953	433	74					117	285
1954	462	80					116	301
1955	422	84					118	285
1956	466	85					138	315
1957	406	80					144	288
1958	455		59	19	17	2	142	317
1959	427		43	23	15	3	159	306
1960	422		60	23	16	4	140	304
1961	430		48	18	12	5	125	292
1962	358		43	20	11	5	115	252
1963	414		50	21	10	4	90	269

[a] For 1947-1957, only total data available.
Source: *(6)*.

Appendix Table 14. — Production of Coconut of the Philippines, Ceylon, Malaya, and Indonesia, 1947-1963

Year	Philippines	Ceylon	Malaya	Indonesia	Total oil equivalent
	1,000 long tons				*1,000 metric tons*
1947	980	141	70	410	1,025
1948	870	221	107	600	1,151
1949	685	211	123	700	1,100
1950	770	190	150	670	1,139
1951	1,020	245	160	800	1,424
1952	939	263	154	725	1,332
1953	843	233	152	715	1,244
1954	992	217	164	810	1,397
1955	1,079	285	144	775	1,461
1956	1,297	260	154	810	1,613
1957	1,421	185	130	825	1,639
1958	1,183	166	108	530	1,272
1959	1,945	221	125	545	1,175
1960	1,291	187	173	615	1,450
1961	1,193	272	162	625	1,441
1962	1,255	307	133	500	1,405
1963	1,477	244	137	550	1,541

Source: *(6)*.

Appendix Table 15. — Net Imports of Vegetable Oils and Oilseeds, Japan, 1947-1963

Calendar year	Soybean oil	Cotton seed oil	Rapeseed oil	Sesame seed oil	Groundnut oil	Palm-kernel oil	Coconut oil	Palm oil	Total
	1,000 metric tons, oil equivalent								
1947	2	0	0	0	0	0	9	0	11
1948	5	0	0	0	6	0	14	0	25
1949	36	1	1	0	5	0	10	0	53
1950	34	5	1	1	8	0	24	3	76
1951	54	3	1	4	5	0	25	1	93
1952	30	5	1	2	3	0	17	2	60
1953	75	6	1	5	2	0	19	3	111
1954	83	9	0	6	2	3	25	12	140
1955	137	12	10	8	5	9	32	32	245
1956	122	13	15	10	3	12	25	26	226
1957	124	10	9	5	4	13	29	14	208
1958	144	15	7	8	3	14	30	10	231
1959	155	21	11	13	2	15	35	17	269
1960	181	16	21	13	3	14	54	13	315
1961	181	18	8	10	1	11	50	15	294
1962	225	28	15	13	1	11	56	14	363
1963	275	34	30	13	5	11	68	17	453

Source: *(16)*.

Appendix Table 16.—Net Imports of Vegetable Oils and Oilseeds, Western Europe, 1947-1963

Calendar year	Sesame seed oil	Sunflower seed oil	Olive oil	Rape-seed oil	Cotton-seed oil	Soybean oil	Ground-nut oil	Coconut oil	Palm-kernel oil	Palm oil	Total
						1,000 metric tons					
1947	5	31	−13	7	25	47	246	576	241	234	1,399
1948	15	52	19	12	35	46	417	518	270	303	1,687
1949	14	34	1	−36	51	224	490	539	329	401	2,047
1950	14	91	19	−29	53	150	472	512	333	451	2,066
1951	11	91	−6	2	55	303	382	771	327	416	2,352
1952	18	30	6	−1	38	142	439	675	333	473	2,153
1953	51	14	1	14	78	150	491	524	336	491	2,150
1954	10	16	−7	10	151	125	538	589	343	462	2,237
1955	7	13	−3	−9	143	214	553	601	281	402	2,202
1956	16	12	−4	−5	183	416	643	688	333	459	2,741
1957	10	12	33	4	183	433	620	759	317	461	2,832
1958	10	20	−2	11	86	486	667	537	339	459	2,613
1959	11	29	36	19	153	614	669	402	309	462	2,704
1960	14	59	−7	32	169	688	587	584	297	457	2,880
1961	15	98	−3	16	115	594	643	642	283	440	2,843
1962	21	85	25	2	80	732	716	512	280	334	2,787
1963	19	179	67	−13	113	654	743	576	270	338	2,946

Source: *(16)*.

Appendix Table 17. — Supply and Disappearance of Soybean Meal and Supply of Other High-Protein Feeds in the United States, 1948-1964

Year[a]	Domestic disappearance	Free ending stocks (meal and bean form)	Exports (meal and bean form)	Total commercial availability	Supply of other high-protein feeds
			1,000 metric tons		
1948-49	3,794	80.1	627.9	4,502.0	5,140
1949-50	4,125	93.7	322.3	4,541.0	5,333
1950-51	5,219	90.0	790.0	6,099.0	5,264
1951-52	5,148	124.0	401.0	5,673.0	5,591
1952-53	5,030	267.3	723.7	6,021.0	5,503
1953-54	4,535	84.1	908.9	5,528.0	6,064
1954-55	4,956	104.1	1,546.9	6,607.0	5,604
1955-56	5,512	179.8	1,804.2	7,496.0	5,962
1956-57	6,468	150.3	2,223.7	8,842.0	5,562
1957-58	7,257	197.2	2,096.8	9,551.0	5,319
1958-59	8,143	146.6	2,814.3	11,103.9	5,603
1959-60	7,699	363.5	3,606.5	11,669.0	5,709
1960-61	8,051	198.9	3,312.1	11,562.0	6,044
1961-62	8,410	225.4	4,235.1	12,870.5	6,305
1962-63	8,704	430.3	5,187.7	14,322.0	6,393
1963-64	8,319	562.0	5,425.0	14,306.0	6,709

[a] Beginning October 1.
Sources: Supply of other high-protein feeds, *(32)*; others, *(31)*.

Appendix Table 18. — Livestock Prices and High-Protein Consuming Animal Units, Canada, Japan, Europe, and United States, 1948-1963

Year[a]	Livestock prices		High-protein consuming units, United States	Livestock numbers, Canada, Japan, and Europe	
	United States, 1914-18=100	Europe and Canada, 1957-58=100		Cattle	Hogs
				million	
1948	283.9	93.0	130.9	77.1	43.5
1949	268.5	82.0	134.2	78.5	42.3
1950	328.1	93.5	135.3	79.7	45.3
1951	316.7	96.3	137.0	80.2	50.3
1952	278.5	91.2	133.8	82.4	51.1
1953	262.9	92.4	133.5	84.0	51.3
1954	237.5	91.7	135.0	84.7	53.5
1955	225.5	97.3	138.4	85.2	54.3
1956	237.1	100.3	136.6	84.2	56.0
1957	268.3	100.0	135.8	87.3	58.9
1958	262.5	98.7	140.8	89.1	60.8
1959	248.9	96.9	139.6	90.9	60.7
1960	253.0	102.4	142.9	94.0	63.3
1961	252.7	104.7	143.3	96.1	68.2
1962	249.3	113.3	145.9	95.4	67.0
1963	236.0	115.4	147.1	94.7	69.4

[a] Beginning October 1.
Sources: United States livestock prices and high-protein consuming units, *(32)*; European, Japanese, and Canadian livestock numbers, *(15)*; European and Canadian livestock prices, *see text, p. 20*.

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3M—3-67—92054